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Assessment of the Impacts of Industrial Discharges on Publicly Owned Treatment Works: Appendicies

JRB Associates, Inc.
McLean, VA

Prepared for

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ASSESSMENT OF THE IMPACTS OF INDUSTRIAL DISCHARGES ON PUBLICLY OWNED TREATMENT WORKS

FINAL REPORT

Submitted to the Environmental Protection Agency

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The Regulatory Impact Analysis Report (Final) was prepared to evaluate the General Pretreatment Regulations (40 CFR 403) and a range of possible alternative regulatory strategies/options in a manner consistent with the intent of Executive Order 12291. This evaluation examined the need to protect the operations of publicly owned treatment works (POTWs) from industrial discharges, the potential contamination of POTW sludge, and the need to control the pass through of toxic pollutants specifically included in EPA categorical pretreatment standards for industries.

The analysis focuse on identification of key policy issues and relevant data and use of analytical techniques to assist EPA in evaluating the General Pretreatment Regulations. The report presents informations collected, the analyses conducted, and significant findings of this effort. In addition, more detailed information is provided on the data and discrete analyses which support this report in an accompanying Appendix. An extensive bibliography is included in the Appendix which catalogues the numerous data sources used in the project. Finally, a discrete computer model has been developed and is currently operational on the EPA computer which generates data valuable to the assessment of regulatory options for the control of industrial wastes at POTWs.

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ASSESSMENT OF THE IMPACTS
OF INDUSTRIAL DISCHARGES
ON PUBLICLY OWNED TREATMENT WORKS

FINAL REPORT

November 20, 1981

This document has been prepared pursuant to
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November 20, 1981

Mr. Thomas O'Farrell
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Dear Mr. O'Farrell:

Enclosed is our final report and accompanying appendices on the impacts of industrial discharges on POTWs. The document provides a thorough discussion of the data and methods used in and findings of the project. The comments of the EPA staff who reviewed the earlier drafts are addressed in this report.

I think that the modifications we made provide a better framework than earlier drafts for understanding the complexity of pretreatment issues. Still, the report is a technical submission. It is not intended to be a complete Regulatory Impact Analysis although the report addresses most of the elements of OMB's RIA directive.

If I can be of any further assistance to you, please call on me. It has been a pleasure working on this project with you and the other members of the EPA working group.

Sincerely,

Edward R. Saltzberg

Edward R. Saltzberg, Ph.D.
Business Area Manager

ERS:wd
Enclosure

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STATEMENT OF THE PURPOSE OF THE PROJECT

Scope

The purpose of this project is to evaluate the General Pretreatment Regulations (40 CFR 403) and a range of possible alternative regulatory strategies in a manner consistent with the intent of Executive Order 12291. In this evaluation, we examine the need to protect the operations of publicly owned treatment works (POTWs) from industrial discharges, the potential contamination of POTW sludge, and the need to control the pass-through of toxic pollutants specifically included in EPA categorical pretreatment standards for industries.

The General Pretreatment Regulations have two primary components. The basic provisions of the regulations direct municipalities to control discharges which interfere with, bypass or pass-through the POTW. In addition, they cover administrative procedures, surveys of industries which use the POTW, enforcement, and reporting requirements. The other component of the Regulations cover delegation to the POTW of the federal authority to enforce EPA-set toxic limits for categorical industries. These two components of the Regulations are separate and distinct.

Problems related to upset and bypass resulting from industrial discharges were examined in this study. We were able to analyze the extent of these operational problems using POTW inspection reports and the findings of visits to municipalities in other projects. Operational problems can cause the discharge of untreated wastes into receiving waters and can increase operating costs to POTWs. These problems were found to be pervasive and a significant motivation for the development of industrial waste control programs in existence today. The causes of upset and bypass are highly variable, case specific, and therefore very difficult to address on a national level. The basic provisions of the General Pretreatment Regulations require that local programs be developed to address problems affecting the integrity of POTW operation. Since this basic 403 program calls for a minimal and flexible local response to address these operational problems, no alternatives to the basic provisions were evaluated.

The emphasis of this study was on the analysis of the second component of the General Pretreatment Regulations -- the control of pass-through and sludge contamination through the application of categorical pretreatment standards to industries by POTWs. This study focused on four major questions:

1) Does the pass-through of toxic pollutants pose pervasive water quality problems?

2) Is the uniform application of categorical pretreatment standards needed to address these water quality concerns?

3) Can a reduced program of categorical pretreatment standards achieve much of the benefits of the full program at a lower cost?

4) Is the contamination of POTW sludge by toxics a significant problem?

After determining the nature of the environmental problems, alternatives to the current program were developed. The options range from being based on national uniform requirements to options whose requirements reflect local problems and solutions. The options vary in terms of whether the control point is at the industry or at the POTW. The options also vary in terms of the level of federal involvement and reliance on local initiative. Within the limits of the available data, the costs and benefits of each option were estimated.

Pretreatment is not an independent environmental program. In itself it does not directly regulate environmental problems. What it regulates is the pollution loads in the discharge of industrial users of sewers. Other provisions of the Clean Water Act and the Resource Conservation and Recovery Act were developed by Congress to regulate environmental quality; mainly through sludge and water quality criteria and standards. The fact that these standards are not widely accepted in some cases, or have not been finalized in others is a limitation of this analysis. It is very difficult to assess the environmental benefits of pretreatment without the compliance boundaries established by other programs being in place.

1. INTRODUCTION

Industries may discharge wastewater into the Nation's surface waters in one of two ways - either directly into navigable waters or through publicly owned treatment works (POTWs). The former are termed direct dischargers; the latter are called indirect dischargers (or industrial users). POTWs which receive industrial wastes employ treatment processes in an effort to remove pollutants and then themselves discharge effluent to surface waters. Congress, in the Federal Water Pollution Control Act of 1972, and the Clean Water Act of 1977 established separate regulatory mechanisms for these two classes of point source dischargers. Direct dischargers are subject to effluent standards and water quality standards applied in limitations set in each firm's NPDES permit. Indirect waste dischargers are regulated by the General Pretreatment Regulations (40 CFR 403) and Pretreatment Standards for New and Existing Sources which are enforced by POTWs receiving industrial wastes or by State or Federal authorities. This second regulatory program - to control the indirect discharge of industrial wastes into the Nation's waters - also known as the National Pretreatment Program, is the program under evaluation in this report. Table 1-1 list the 22 categorical industries which are known to discharge toxic pollutants. It is these industries which are the objects of the program under evaluation.

Pursuant to the recently issued Executive Order 12291, major pending regulations (among others) must be analyzed to ensure that underlying strategies chosen maximize net benefits to society. To meet this goal, Regulatory Impact Analyses (RIAs) are to be prepared which evaluate the costs and benefits of the alternative strategies examined by the regulations. The General Pretreatment Regulations, issued on June 26, 1978 and amended on January 28, 1981, were identified by the President's Task Force on Regulatory Relief/The Office of Management and Budget for evaluation by the Environmental Protection Agency. As categorical pretreatment standards and the General Pretreatment Regulations are mutually interdependent, the focus of this analysis was expanded to encompass a review of the full National Pretreatment Program with particular emphasis on the control of toxic pollutants. This document reports the findings of a project by contractors to provide EPA with technical information important to the preparation of this RIA. The remainder of this Chapter covers basic information on 1) The magnitude of the indirect water pollution problem; 2) The characteristics of POTWs receiving industrial wastes and the degree of toxics control at POTWs; 3) How the National Pretreatment Program regulates indirect discharge and POTWs; and 4) An overview of the approach used in this project to evaluate the National Pretreatment Program. Chapter 2 introduces the criteria for assessing the impacts of indirect discharges and discusses analytical methodologies used in the project to investigate environmental impacts, costs, and benefits. Chapter 3 presents findings of the assessment of the need for control of industrial dischargers to POTWs. Finally, Chapter 4 contains an analysis of the pretreatment alternatives evaluated in this study.

1.1 COMPARISON OF DIRECT AND INDIRECT DISCHARGES OF TOXIC POLLUTANTS

A major rationale for the regulation of both direct and indirect discharges is their discharge of toxic pollutants - primarily metals and organic chemicals - into waters. Table 1-1 provides a perspective of the magnitude of toxic pollutants discharged by both classes of discharges. It was compiled from data provided by the Effluent Guidelines Division of the Environmental Protection Agency (EPA). The table shows annual national estimates of raw wasteloads, current wasteloads (with the amount of partial controls in place estimated by EPA), and ultimate wasteloads if all regulations are met [Best Available Technology, (BAT) regulations for direct dischargers and Pretreatment Standards for indirect dischargers] for the major industrial sources of toxic water pollutants. Table 1-1, shows that indirect dischargers are responsible for the generation of 35 percent of the combined industrial output of raw total metal and organic wastes nationally — 34 percent of the raw wasteload of metals and 36 percent of raw total toxic organics. When these calculations are performed on EGD estimates of the levels of current control in place, indirect dischargers account for 60 percent of the total metals and toxic organics discharges for industry - 61 percent of all metals and 59 percent of all toxic organic discharges. At full controls, indirect dischargers generate 54 percent of total metals and toxics.

Table 1-1. Comparison of Direct Versus Indirect Discharges*

Indirect Discharge**

Industry	Total Toxic Metals (Pounds/Year) Raw	Current	BAT	Total Toxic Organics (Pounds/Year) Raw	Current	BAT
Metal Finishing/ Electroplating	120,000,000	32,000,000	3,500,000	98,000,000	26,100,000	12,100,000
Iron and Steel	12,000,000[†]	3,100,000	72,000	29,000,000	7,200,000	1,200,000
Leather Tanning	5,700,000	5,700,000	400,000	582,000	580,000	580,000
Aluminum Forming	6,400,000	4,300,000	0		210	40
Pulp, Paper, Paperboard	3,800,000	3,800,000	3,800,000	1,000,000	1,000,000	1,000,000
Inorganic I & II	3,300,000	1,400,000	50,000	–	–	–
Porcelain Enameling	1,400,000	1,300,000	0	–	–	–
Copper Forming	970,000	970,000	20,000	–	–	–
Organics & Plastics	790,000	707,000	79,000	171,000,000	154,000,000	43,000,000
Textiles	580,000	580,000	570,000	1,050,000	1,050,000	1,050,000
Petroleum Refining	560,000	560,000	560,000	2,000,000	2,000,000	2,000,000
Foundries	1,700,000	330,000	0	220,000	60,000	–
Coil Coating	380,000	210,000	210,000	3,300	1,900	1,900
Electrical	160,000	160,000	160,000	313,000	230,000	60,000
Battery	2,300,000	150,000	0	103	90	1
Non Ferrous	–	130,000	10,000	1,600	630	620
Paint	610,000	130,000	130,000	300,000	40,000	39,000
Steam & Electric	20,000	20,000	2,000	–	–	–
Pesticides	24,000	16,000	0	240,000	240,000	30,000
Timber	6,500	6,200	6,200	110,000	45,000	45,000
Ink	2,000	1,900	600	8,900	1,300	1,300
Pharmaceuticals	53,000	–	–	–	–	–
Totals	160,000,000	56,000,000	9,600,000	300,000,000	190,000,000	61,000,000

Direct Discharge

Industry	Total Toxic Metals (Pounds/Year) Raw	Current	BAT	Total Toxic Organics (Pounds/Year) Raw	Current	BAT
Metal Finishing/ Electroplating	44,000,000	1,500,000	1,500,000	33,000,000	9,600,000	4,000,000
Iron and Steel	18,000,000[†]	2,400,000	580,000	25,000,000	4,800,000	260,000
Leather Tanning	530,000	83,000	18,000	90,000	15,000	4,000
Aluminum Forming	4,500,000	2,800,000	0	–	410	250
Pulp, Paper, Paperboard	4,600,000	2,600,000	2,600,000	8,600,000	620,000	520,000
Inorganic I & II	7,900,000	700,000	140,000	–	–	–
Porcelain Enameling	270,000	260,000	0	–	–	–
Copper Forming	590,000	590,000	20,000	–	–	–
Organics & Plastics	154,000,000	7,100,000	2,700,000	447,000,000	112,000,000	46,000,000
Textiles	470,000	380,000	220,000	710,000	86,000	52,000
Petroleum Refining	1,300,000	560,000	280,000	5,900,000	20,000	10,000
Foundries	11,000,000	1,700,000	0	1,400,000	390,000	0
Coil Coating	440,000	260,000	0	4,000	2,400	0
Electrical	62,000	62,000	62,000	104,000	99,000	19,000
Battery	680,000	200,000	–	77	73	0
Non Ferrous I	63,000,000	14,000,000	0	19,000,000	6,900,000	600,000
Paint Forming	21,000	5,900	500	80,000	1,300	1,300
Steam & Electric	700,000	700,000	20,000	–	–	–
Pesticides	21,000	11,000	1,000	320,000	15,000	1,000
Timber	–	–	–	–	–	–
Ink	–	–	–	–	–	–
Pharmaceuticals	29,000	11,000	–	–	–	–
Totals	310,000,000	38,000,000	8,100,000	540,000,000	130,000,000	50,000,000

*Does not include Paragraph 8 subcategories, and based on EPA projections

**Loadings are estimation of pounds discharged into sewers prior to treatment at the POTW

[†] Refers to 1972 discharge

Table 1-1 also demonstrates that, in gross terms, the metal finishing/electroplating industry is the greatest contributor of toxic pollutants vis-a-vis other indirect dischargers. This fact was the basis for EPA's promulgation of categorical standards for the electroplating industry as the first pretreatment standard to be issued. It is also the reason for the Agency's selection of a "metal finishers only" pretreatment option for evaluation later in this report.

The discharge from industrial users receives further treatment by the POTW. Although municipal treatment works are rarely designed to process toxic pollutants, there is a significant amount of incidental removal of toxics by POTWs. Metals removed from the influent of POTWs concentrate in the sludge and toxic organics volitalize or are decomposed by the facility's biological treatment processes. At secondary treatment plants a representative removal efficiency for metals is 60 percent and 79 percent for toxics (see Appendix C-2). Accordingly, much of the mass of metals and organics in the discharge from industrial users does not reach surface waters. Table 1-2 reports the actual fate of metals generated by indirect dischargers. It was prepared by applying the representative secondary treatment removal efficiency for metals to the data in Table 1-1. (For comparison, Table 1-2 also lists the fate of metals generated by direct dischargers.)

As pretreatment implementation advances to full controls under 40 CFR 403 the metals discharged to surface water through POTWs and concentrated in municipal sludge decreases drastically. Metal concentrations in industrial sludges increase a like amount. In many respects the value of pretreatment is determined by the relative importance of the distribution and fate of pollutants generated by industrial dischargers.

TABLE 1-2

COMPARISON OF DIRECT AND INDIRECT DISCHARGES OF TOTAL HEAVY METAL

Degree of Industrial Treatment
(lbs/yr x 1,000,000)

Fate of Pollutant	Raw	Current	403
	Indirect Contributions*		
Industrial Wastewater	160	56	9
Waterbody	64	22	4
Industrial Sludge	-	104	151
Municipal Sludge	96	34	5
	Direct Contribution		(BAT)
Industrial Wastewater	312	35	8
Industrial Sludge	-	277	304

* Assumes that POTW removes 60% of the metals from the industrial wastewater which is concentrated in the municipal sludge.

Tables 1-1 and 1-2 provide an overview of the magnitude and relative importance of toxics contributions from indirect dischargers but do not allow meaningful estimates to be derived for the environmental impacts of these wasteloads. The volume and relative mix of toxic wastes from indirect discharges received by POTWs varies from plant to plant, as does the POTW's removal efficiency, its level of wastewater treatment (primary, secondary, tertiary) and the characteristics of the POTW's receiving waters. These variables are the key determinants of the environmental impacts of indirect toxic discharges. The majority of our effort on this project has been to collect data and develop modeling tools which allocate these pounds of toxic pollutants to POTWs in a realistic manner to allow an estimation of the impacts they have on water and sludge quality at municipalities. These impacts were then aggregated back to the national level to allow conclusions to be made on the National Pretreatment Program and other regulatory alternatives to control the indirect discharge of toxic pollutants.

1.2 POTW DEMOGRAPHICS

The preceding discussion introduced the industrial waste component of the pretreatment program. The second major group of regulatees under the general Pretreatment Regulations are the POTWs which receive industrial wastes. The following section presents basic information on Publicly Owned Treatment Works to provide a background understanding of their aggregate physical characteristics and the impacts that industrial wastes may have. These characteristics include wastewater flow, industrial flow, sludge handling methods and level of treatment.

1.2.1 Wastewater Flow

There are 15,250 complete wastewater treatment facilities[1] in the U.S. today. These 15,250 POTWs have a total influent flow of approximately 26 billion gallons per day (bgd) and a total industrial flow of 4.4 (bgd). The 2,000 POTWs estimated by EPA to need pretreatment programs treat 81 percent (21.1 bgd) of the total national flow and 91 percent (4 bgd) of the national industrial flow to POTWs. Sixty percent of the industrial flow is from categorical industries, the rest of the industries flow is attributed to non-categorical or commercial sources. Most of the industries in the country subject to the categorical pretreatment standards discharge to the POTWs regulated by the General Pretreatment Regulations. Table 1-3 summarizes key physical charateristics of the POTWs subject to the pretreatment regulations.

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[1] Although there are 32,000 municipal waste handling systems in the country, only 15,250 treat wastewater and produce a sludge. The remaining include septic systems, pumping stations or sludge handling facilities.

POTWs handle their treated effluent discharge in the following manner:

- 83.6 percent of the total flow or 17.6 bgd goes to surface waterbodies,
- Of those plants discharging to surface waterbodies, 86 percent or 15.1 bgd goes to rivers and streams, the rest to lakes and bays,
- 12.1 percent of the total flow or 2.5 bgd is discharged to the ocean,
- The remaining discharge is distributed among a number of disposal alterations, including:
    - groundwater recharge and deep well injection
    - irrigation and land disposal
    - recycling and holding ponds.
- 60% of plants (1189) have less than 15 percent industrial flow.

1.2.2 Type of Treatment

Three types of treatment systems are commonly used at POTWs. Primary treatment is a physical sedimentation process for removing settleable solids, secondary treatment is a physical/biological process for removing solids, BOD, and pH, and tertiary treatment is a process which accomplishes secondary treatment with an additional capability to remove or alter other pollutants.

Table 1-4 shows the amount of flow processed by POTWs and indicates the average efficiency of primary, secondary and tertiary treatment. Most municipal waste receives secondary treatment.

TABLE 1-3. DISTRIBUTION OF POTWS BY AVERAGE DAILY FLOW

AVER. DAILY FLOW		PERCENT INDUSTRIAL FLOW					
		0-15	15-20	20-30	30-40	40-50	50-100
0-1 MGD	TOTAL FLOW	158	16	19	15	6	17
	INDUSTRIAL FLOW	3	3	4	5	3	12
	NO. OF PLANTS	378	32	37	30	16	34
1-5 MGD	TOTAL FLOW	1,070	134	180	116	113	213
	INDUSTRIAL FLOW	41	23	45	41	51	148
	NO. OF PLANTS	422	59	73	47	42	86
5-20 MGD	TOTAL FLOW	2,717	439	683	567	268	321
	INDUSTRIAL FLOW	123	79	174	200	120	225
	NO. OF PLANTS	292	43	67	53	25	36
20-50 MGD	TOTAL FLOW	1,690	249	628	306	279	526
	INDUSTRIAL FLOW	116	43	157	111	126	356
	NO. OF PLANTS	57	10	19	11	9	17
50-100 MGD	TOTAL FLOW	1,609	313	289	352	293	82
	INDUSTRIAL FLOW	108	36	68	119	128	52
	NO. OF PLANTS	22	5	4	5	4	1
> 100 MGD	TOTAL FLOW	2,966	1,436	1,752	1,153	122	—
	INDUSTRIAL FLOW	192	235	404	394	49	—
	NO. OF PLANTS	18	4	7	6	1	0

TABLE 1-3 (Continued) DISTRIBUTION OF POTWS BY LEVEL OF TREATMENT

	PRIMARY			SECONDARY			TERTIARY		
PERCENT INDUSTRIAL FLOW	NO. OF PLANTS	TOTAL FLOW (MGD)	INDUSTRIAL FLOW (MGD)	NO. OF PLANTS	TOTAL FLOW (MGD)	INDUSTRIAL FLOW (MGD)	NO. OF PLANTS	TOTAL FLOW (MGD)	INDUSTRIAL FLOW (MGD)
0-15	228	2960	198	914	6831	360	47	418	25
15-20	26	784	131	119	1720	292	8	84	16
20-30	25	761	201	166	2597	628	16	93	23
30-40	16	187	64	131	2201	765	5	119	41
40-50	16	388	167	78	667	297	3	26	12
> 50	32	184	135	133	879	597	9	96	61

Table 1-4

	% of Flow	Flow (bgd)
Primary	25	5.3
Secondary and Advanced Secondary	71	15.0
Tertiary	4	0.8

The table shows that although secondary treatment is most common, much of the nation's industrial flow only receives primary treatment. Twenty-five percent of the total flow is processed by primary treatment plants. This is significant because secondary plants remove 70 percent of the toxic pollutants on average by incidental removal, while at primary plants only 35 percent of the toxics are removed.

Five major sludge disposal technologies are commonly used by POTWs; incineration, landfilling, land spreading, trenching and ocean dumping. Table 1-5 depicts the amount (in tons/year) of sludge disposed by primary, secondary and tertiary treatment facilities for each disposal method. Sludge quality numbers vary tremendously from one plant to another, making it difficult to estimate a representative sludge concentration value for each type of treatment. However, because of the differences in removal efficiences, the sludge generated at secondary plants will contain more toxic pollutants than that generated at primary facilities. Five times as much sludge is generated at secondary plants than at primary plants.

The aggregate characteristics of POTWs measured by total flow, percent industrial flow and level of treatment do not vary significantly among EPA regions. Where this similarity ends is in sludge disposal methods and method of liquid effluent disposal. Ocean dumping of sludge and effluent is confined to coastal States. Irrigation occurs mostly in Arizona, Nevada, New Mexico and California.

TABLE 1-5

POTW SLUDGE DISPOSAL METHODS

	(Number of Plants)	Tons/Year Primary	Secondary	Tertiary	Total
Incineration	(280)	193,791	772,915	100,726	1,121,132
Landfill	(1163)	250,849	1,463,593	164,607	1,879,049
Land Spread	(481)	15,445	254,638	30,221	300,304
Trenching	(4)	794	18,386	-	19,630
Ocean Dumping	(300)	133,567	266,884	-	400,451
Total		594,446	2,776,866	295,554	3,666,866

*Some plants use more than one disposal method, this is reflected in double accounting of the disposal alternatives.

1.2.3 Conclusions

The following conclusions can be drawn from assessing POTW demographics for the 2,000 POTWs estimated to need pretreatment:

- The 2,000 POTWs estimated to have pretreatment account for 81 percent of the total POTW flow in the nation and 91 percent of the total POTW industrial flow.
- Most of the industries subject to categorical pretreatment standards discharge to the 2,000 POTWs.
- 1,441 of the 2,000 POTWs are at secondary treatment.
- Primary treatment plants process 25 percent of the total flow for the 2,000 POTWs.
- 84 percent of the total flow from the 2,000 POTWs is discharged to non-marine surface water bodies.
- The total volume of sludge generated by secondary treatment plants is 5 times the amount generated by primary plants.
- In general, sludge generated at secondary plants contain more toxics than that generated by primary treatment facilities.
- 49 percent of the total flow from the 2,000 POTWs falls in the range of 0 to 15 percent industrial flow. Although this range seems low, it is strongly influenced by the largest cities (>200 mgd) which have a low percentage of industrial flow even though they have a large number of industrial discharges. Support for this finding appears in Appendix A (under separate cover).
- Small plants (those under 5 mgd) typically have more than 25 percent industrial flow.

1.3 DESCRIPTION OF THE NATIONAL PRETREATMENT PROGRAM

In 1972, Congress cited the need for a national mechanism to protect POTWs and the environment from various problems associated with industrial wastewater discharges to municipal sewers. Through Section 307 of the Federal Water Pollution Control Act, Congress directed the EPA Administrator to establish wastewater discharge standards for industrial users of publicly owned treatment works

(POTWs) "to prevent the discharge of any pollutant through treatment works... which pollutant interferes with, passes through, or is otherwise incompatible with such treatment works." Incompatibility applies to both wastewater discharge quality and the sludge. The following discussion examines the evolution and workings of the current federal regulatory approach for the control of industrial wastes at POTWs receiving industrial wastes which constitutes the National Pretreatment Program. The requirements and procedures of the General Pretreatment Regulations (40 CFR 403), and Categorical Pretreatment Standards, are presented in this section along with the interrelationships of these regulations with other Clean Water Act provisions and environmental statutes. This section is intended to establish the regulatory backdrop for the subsequent analyses of alternative pretreatment programs, and define the method of analysis used in this study. More detailed legal and programmatic information is available in Appendices A-2 and A-4.

1.3.1 Evolution and Scope of the National Pretreatment Program

The initial strategy to control industrial discharges to POTWs was detailed by EPA in the original pretreatment regulations (40 CFR 128 in 1973). These provisions required major industrial dischargers to comply with effluent guidelines (established by EPA) defining best practicable treatment for the removal of pollutants incompatible with the operation of POTWs. Technological uncertainties and administrative delays hindered EPA's promulgation of guidelines and standards and in 1976 EPA was sued by several environmental groups. The Toxics Settlement Agreement which resulted from this suit (NRDC v. Train 12 ERC 1833) required EPA to develop a program and adhere to a schedule for promulgation of Best Available Technology (BAT) effluent limitations and pretreatment standards for 21 major categories of industries covering 65 "priority" toxic pollutants. This national and uniform approach for the control of toxic pollutants was incorporated into the Clean Water Act (CWA) of 1977, which amended the Federal Water Pollution Control Act.

The 1978 General Pretreatment Regulations (40 CFR 403) revised the 1973 provisions and were issued to provide a framework and delineate responsibilities for the application of pretreatment standards. A range of alternative pretreatment strategies were considered during this regulations-development process. The alternatives varied in terms of the extent to which industrial users of POTWs would be controlled by national technology-based pretreatment standards, the amount of local flexibility allowed, and the relative roles of the federal, State, and local governments. The approach finally selected in the General Pretreatment Regulation (40 CFR 403, June 26, 1978, amended January 28, 1981) places principal authority for implementation and enforcement with municipalities.

Municipal responsibilities under the General Pretreatment Regulations are essentially two-fold:

- General responsibilities to protect plant operations and local environmental quality.
- Specific responsibilites to implement and enforce national categorical standards.

These responsibilities which are separate and distinct, are discussed in the following two sections.

1.3.2 General Pretreatment Provisions Under 40 CFR 403

This responsibility entails the development and implementation of an administrative program to deal with the site-specific and unique problems that the POTW experiences due to non-domestic contributions of conventional and other pollutants which interfere with or upset the operation of the POTW. The 403 Regulations contain generic "prohibited discharge standards" for such parameters as pH, corrosivity, flammability, and heat to assist POTWs in protecting plant operations. Under the 403 program, municipalities are required to survey industrial users and identify the types and volumes of industrial pollution they receive. Industrial waste-related plant problems are to be analyzed and effluent limitations are to be developed to protect the POTW from prohibited discharge. Mechanisms for permitting, monitoring, and enforcement must be designed and administered to implement controls on industrial discharges of detrimental conventional wastes. POTWs then work with existing industrial users to bring about the installation of pretreatment technologies, process changes, or the like to control deleterious discharges. (In contrast, categorical industries must comply with Federally-set pretreatment standards.) New industrial contributors may be required to incorporate pretreatment in the facility design before being allowed to connect to the POTW system. Monitoring is performed to assure compliance. Where violations are found, enforcement actions are to be brought.

1.3.3 National Categorical Standards for Industry

Two separate regulatory mechanisms were established for indirect dischargers in the CWA. Section 307(b) of the Act requires EPA to promulgate pretreatment standards for existing sources (PSES) which must be met within three years of promulgation. Section 307(c) requires pretreatment standards for new sources (PSNS). Both sets of standards deal primarily with toxic pollutants and are to prevent the discharge of pollutants which pass-through, interfere with, or are otherwise incompatible with the operation of POTWs.

The Settlement Agreement and §307 of the Clean Water Act establish a parity between direct and indirect dischargers in the control of priority pollutants. Categorical pretreatment standards require pollution reduction such that the combination of industrial pretreatment and treatment at the POTW are equal to the pollution reduction attained by a direct discharger meeting BAT standards. The designation of industries for which standards must be developed was recategorized by EPA to cover 34 industries.

Firms in these categorical industries are believed by EPA to be the major sources of toxic pollutants. They contribute about 60 percent of the volume of industrial wastes to POTWs. EPA does not establish specific discharge standards for firms in non-categorical industries because they are not major sources of toxics. However, these firms can be regulated locally under the general prohibitions of the General Pretreatment Regulations.

To date, two sets of pretreatment standards have been developed — one for the electroplating industry and the the other for the timber products processing industries. The electroplating standards (40 CFR 413) were first issued on September 7, 1979, have gone through three revisions, and were amended on January 28, 1981. Certain portions of the electroplater regulations pertaining to captive facilities, as opposed to the smaller job shops, are not yet in effect. The timber products processing pretreatment standards (40 CFR 429) were issued on January 26, 1981.

A major role for municipalities required to have 403 programs is to implement and enforce PSES's and PSNS's for categorical industries discharging to their POTWs. Categorical industrial users, identified in the industrial waste survey, must be apprised of the existence of national pretreatment standards by the control authority. The administrative devices of local pretreatment programs discussed above may then be applied to assure compliance. In addition, POTWs may apply for removal credits which, if approved by EPA, may be passed on to categorical industrial users.

1.3.4. Applicability of the Program

Two groups of POTWs must develop programs under the General Pretreatment Regulations. POTWs with total flows greater than 5 million gallons per day (mgd) and which receive wastes from industries subject to national pretreatment standards must develop and operate pretreatment programs. Compliance schedules have been inserted into the discharge permits issued to these POTWs to ensure that they will have programs in place by July 1, 1983. These permits are issued under EPA's National Pollutant Discharge Elimination System (NPDES). POTWs with total flows less than five mgd may also be required by EPA to establish programs where warranted by special problems with industrial discharges. NPDES States (with EPA approval to issue NPDES permits) which develop approvable State pretreatment programs receive full NPDES delegation to oversee pretreatment activities in their States. NPDES States may also choose to operate State-wide programs and assume implementation and enforcement authority in lieu of municipalities. EPA Regional offices will implement and enforce pretreatment in non-NPDES States and in NPDES States rejecting pretreatment delegation.

1.3.5 Other Environmental Provisions and Laws Affecting The National Pretreatment Program

Categorical pretreatment standards afford a mechanism for the control of the pass-through of toxics at POTWs, while the 403 program regulates conventional pollutants and provides an overall administrative framework for implementation and enforcement of the National Pretreatment Program. Other Clean Water Act provisions and environmental statutes provide further financial or environmental incentives for the control of industrial wastes by pretreatment. These provisions are discussed below.

1.3.5.1 Financial Incentives under the Clean Water Act

The Federal government provides financial incentives to POTWs for development of pretreatment programs by underwriting 75 percent of development costs in §201 construction grants. As shown in Table 1-6, almost 40 million dollars has been obligated in municipal construction grants for pretreatment since 1977.

TABLE 1-6
CONSTRUCTION GRANTS FUNDS OBLIGATED FOR PRETREATMENT ($THOUSANDS)
(See Appendix A-4 for Data Sources)

EPA Region	I	II	III	IV	V
Grant $ Total	2,500	11,221	4,874	1,245	9,240
EPA Region	VI	VII	VIII	IX	X
Grant $ Total	3,352	2,041	331	2,348	1,800

TOTAL: $38,952

States may also be eligible for §201 grants for pretreatment. In addition, §106 grants and §205(g) allotments may be used to administer State pretreatment programs.

1.3.5.2 Performance Standards for POTWs

A variety of standard setting and enforcement provisions in the Clean Water Act encourage the application of pretreatment to control industrial wastes at POTWs. The NPDES program, §402 of the CWA, requires that point sources, including POTWs which discharge to navigable waters, must obtain permits. Written into POTW NPDES permits are plant-specific effluent limitations to assure that the facility complies with applicable technology-based performance standards [Secondary Treatment by 1977 and Best Practical Waste Treatment Technology by 1983 §§201(g)(2)(A), 301(b), and 304(a)] as well as pretreatment standards. In addition, the NPDES permit is the vehicle for imposition of limits to meet stream-based State or federal water quality standards. These two sets of standards, applied in a POTW's permit, dictate the level of pollution reduction which must be achieved by a municipality. To date, however, the focus of these standards has been on conventional pollutants, very few POTWs have toxic effluent limits in their NPDES permits. Data from a study of 132 POTWs by JRB suggests that between 70 to 80 percent of POTWs subject to 40 CFR 403 do not have NPDES permit limits for heavy metals or toxic organic chemicals (see Appendix B-2).

1.3.5.3 Provisions to Control Sludge Quality Under the Clean Water Act (CWA) and Resource Conservation and Recovery Act (RCRA)

Categorical pretreatment standards and the National Pretreatment Program have also been intended to prevent sludge contamination at POTWs, and are therefore closely tied to municipal sludge disposal requirements established under §405 of the Clean Water Act and §4004 of the Resource Conservation and Recovery Act (RCRA). Any industry discharging pollutants which would interfere with a POTWs ability to meet §405 disposal guidelines must pretreat its wastes. The issuance of removal credits is also tied to the POTW's ability to comply with §405 criteria.

Under joint authority of the Resource Conservation and Recovery Act (RCRA) and §405, limits have been set on the amounts of cadmium and PCBs which may be in solid wastes intended for application on lands used for production of food chain crops. These regulations at 40 CFR 257 also provide guidelines for disposal of sludge incinerator ash and sludge in landfills, surface impoundments, and by land spreading. EPA has also issued a preproposal draft under §405 to regulate the distribution and marketing of sludge and sludge products as fertilizer or a soil conditioner. Extensive development remains to be done to define the safe limits and regulate the disposal of sludge containing any of the other 129 priority pollutants. Pretreatment is the principal means for reducing toxicity levels in municipal sludges.

1.3.5.5 Constraints Imposed by Other Statutes

Reduction of industrial wastes at POTWs by requiring pretreatment is also intended to ease POTW compliance burdens vis-a-vis other environmental statutes. The Clean Air Act requires POTWs choosing to incinerate or dry their sludge to meet National Ambient Air Quality Standards (NAAQS) and New Source Performance Standards (NSPS) for sulfur dioxides, particulate matter, carbon monoxide, hydrocarbons, nitrogen dioxide, ozone and lead, and National Emission Standards for Hazardous Air Pollutants (NESHAPS) for mercury. Further, the Toxic Substances stances Control Act under the PCB regulations specifies incineration practices for sludges containing certain levels of PCBs. As sludge quality improves as the result of a pretreatment program, the cost and efforts needed to meet air standards should decline.

The ban on ocean dumping of municipal sludges, for cities not meeting disposal criteria, to take effect in December of 1981 under the Marine Protection Research and Sanctuaries Act, has had the effect of forcing municipalities to find alternate sludge disposal methods. The improvement of sludge quality afforded by pretreatment has eased this transition for cities such as Philadelphia. The Safe Drinking Water Act establishes maximum contaminant levels for substances such as heavy metals in drinking water. POTWs may affect drinking water sources in a number of ways. A considerable portion of the Nation's drinking water sources are surface waters into which POTWs discharge. Reduction in toxics discharged to these waters should ease the water treatment obligations of municipalities. Leaching of toxic pollutants from municipal sludges to groundwater will also be reduced as sludge quality is improved.

An area lacking any regulatory protection outside the pretreatment program is worker health and safety at the POTW. The Occupational Safety and Health Act specifically exempts national, State, and local governments from its definition of an employer. Thus POTW workers are not protected from job-related health or safety hazards under OSHA. Similarly, State OSHA laws do not provide any mechanism affording sewage treatment workers protection from industrial slug loads of toxic chemicals. The pretreatment program may play an important role in the absence of other worker health and safety protection. This issue is further addressed in Appendix B-4.

1.4 AMOUNT OF AND MOTIVATION FOR INDUSTRIAL WASTE CONTROL CURRENTLY IN PLACE AT POTWs

As mentioned above, EPA has identified approximately 2,000 POTWs which either receive categorical industrial wastes or are experiencing other industrial waste related problems, and therefore will be required to develop local pretreatment programs under the General Pretreatment Regulations. To understand the magnitude of the compliance burden the General Pretreatment Regulations impose on these 2,000 POTWs, and to evaluate the need for federal regulatory stimulation to achieve waste control at POTWs a study was performed of 132 municipalities (statistically representative of the 2,000) to determine the extent to which industrial waste control programs are already in place. Additionally, the motivation for the development of local programs already in existence was explored. The section presents summary results on these questions. Further information is provided in Appendix B-3.

1.4.1 Amount of Industrial Waste Control Currently in Place at POTWs

Table 1-7 summarizes data based on a study of 132 POTWs which are representative of the 2,000 POTWs and indicates that only 25% of these 2,000 municipalities have the essential mechanisms in place to control industrial wastes. These mechanisms defined by JRB as essential to a basic POTW industrial waste control program include (1) the existence of a sewer use ordinance with specific effluent limits, (2) some form of permitting mechanism, and (3) a monitoring and enforcement program. (It should be noted that this 25% figure does not represent formal pretreatment programs under the 403 program, but rather municipalities having the three fundamental elements of a control program. Section 1.5 presents estimates of the number of federally or State-approved 403 programs in place today.)

TABLE 1-7
INDUSTRIAL WASTE CONTROL PROGRAMS IN PLACE AT POTWS

Item	POTWs with ≥5 MGD Flow	POTWs with <5 MGD Flow	Total
Pretreatment In Place (ordinance, permits and enforcement)	n = 65	n = 67	n = 132
Yes	31%	18%	25%
No	66%	75%	70%
Unknown	3%	7%	5%

Other indicators of the extent of and motivation for effective industrial waste control programs may be drawn from the 132 POTW study. For instance, in order to control industrial influents, a POTW must first identify the sources, magnitudes, and characteristics of the industrial wastes it receives. The 132 Study further indicates that (as of March 1981) 64 percent of the POTWs have conducted an industrial waste survey (IWS). However, a majority of these cities completed their IWS within the last three years. This suggests that the federal pretreatment program is a primary motivation for two reasons. First, an IWS is required in the 403 program. Second, 403 provides financial incentives for local program development. Additionally, sixty-six percent of the POTWs examined do not monitor for heavy metals in their influent and 69 percent do not monitor for the presence of toxic organics. A study by JRB of 77 POTWs (See Appendix B) reinforces these findings. Sixty-eight percent of these POTWs have no industrial monitoring programs. Of those that do monitor, only 12 percent monitor for metals and 1 percent for toxic organics. Finally, 30 percent have no knowledge of the quality of their sludge.

1.4.2 Motivation of Industrial Waste Control Currently in Place

As estimated above, about 25% of the 2,000 POTWs subject to the General Pretreatment Regulations have industrial waste control mechanisms in place. Table 1-8 presents reasons cited by municipalities for instituting this industrial control. (Multiple responses were given by some cities and others did not respond.) The primary reason given by POTWs was that the program was required either by the State or Federal Government. The second most frequently cited reason was to protect the POTW from harmful wastes. Sixty-five percent of the programs were motivated by these two reasons.

TABLE 1-8
MOTIVATION FOR IMPLEMENTING A PRETREATMENT PROGRAM

Motivation	n = 81	n = 43	n = 124 responses
POTW cost recovery	13%	0	8%
POTW protection	24%	30%	27%
Sludge Quality Improvement	9%	2%	6%
Water Quality Improvement	9%	7%	8%
Required by State/Fed Authority	38%	37%	38%
POTW Worker H & S	1%	0	1%
No response	6%	24%	12%

Where pass through and operational problems at POTWs contribute to a water quality problem, control of toxics from industrial users may be necessary. The relative significance of government intervention in bringing about controls suggest the importance of some form of government involvement to stimulate toxics control where environmental problems exist. The determination of this need and an assessment of alternatives programs to meet it is the subject of Chapters 2, 3 and 4 of this report.

1.5 STATUS OF PRETREATMENT IMPLEMENTATION

As discussed above, The National Pretreatment Program relies on an intergovernmental, three-tiered administrative system involving the Federal government, States, and municipalities for the development and enforcement of categorical and prohibited pretreatment standards. The following section summarizes the progress that has been made by each in implementing these responsibilities to date.

1.5.1 Municipal Efforts

First line responsibility rests with municipalities required to develop and operate programs under the General Pretreatment Regulations. Approximately 2,000 POTWs have been identified by EPA as requiring formal programs. Table 1-9 estimates the implementation progress that has been achieved to date by these municipalities. The table shows that 188 POTWs or 9 percent of the municipalities subject to the Regulations have applied for approval or are implementing formal pretreatment programs. Further, substantial progress toward approval has been made by 79 percent of POTWs larger than 5 mgd and 45 percent of those POTWs under 5 mgd which must develop programs.

Municipalities have spent about 34.9 million dollars in local revenues and Construction Grants to reach this point. (Table 1-6 indicates that 38.9 million dollars have been obligated for pretreatment. This figure also includes funds spent by States from §201 grants.) A liberal estimate of the total money needed to develop municipal pretreatment programs is 45.8 million dollars (see

TABLE 1-9. POTW PRETREATMENT PROGRAM STATUS

		PRETREATMENT PROGRAM STATUS						
DESIGN FLOW (MGD)	TOTAL # POTW'S	# POTW'S NO ACTION	# POTW'S PLANNING	# POTW'S DEVELOPING	APPLIED FOR APPROVAL	# POTW'S IMPLEMENTING	NO DATA	EST. DEV'T COSTS TO DATE ($ MILLIONS)
0 ≤ 5	1261	714	301	76	38	38	94	5.696
5 >	735	143	245	216	79	33	19	29.204
TOTAL	1996	857	546	292	117	71	113	34.900
PERCENTAGE	100	43	27	15	6	3	6	

See Appendix A-4 for sources.

Appendix A-2 for estimation techniques). Accordingly, municipalities have spent 76 percent of the funds necessary to develop pretreatment programs.

1.5.2 State Efforts

NPDES States may assume responsibility for development and operation of a State-wide pretreatment program, by submitting a program plan and having it approved by EPA. NPDES pretreatment delegation entitles the State to identify POTWs needing programs, review and approve local programs, conduct compliance monitoring, and initiate enforcement actions. Of the 33 NPDES States, 32 could currently receive delegation for State pretreatment programs. (The Virgin Islands was deemed by EPA not to need a pretreatment program.) Table 1-10 shows that to date 8 States or 25 percent of the total have had their programs approved, and 12 others have made substantial progress in obtaining programs and are close to receiving delegation, comprising almost 63 percent of eligible States.

New Jersey, West Virginia, and Puerto Rico are currently applying for overall NPDES delegation and are developing pretreatment plans as a part of their applications. Hence, twenty-three of the soon to be thirty-five eligible States have received or are in the process of applying for NPDES pretreatment delegation. Collectively, eligible States have spent $3.4 million out of an estimated total of $5.9 million or 58 percent of the amount that would be required for full State assumption of pretreatment responsibilities. (For greater detail, see Appendix A-4).

1.5.3 Federal Efforts

Federal activities in the National Pretreatment Program range from categorical standard development by the Effluent Guidelines Division of the Office of Water Regulations and Standards, program implementation and assistance by the Permits Division of the Office of Water Enforcement, financial support from

TABLE 1-10

STATUS OF STATE PRETREATMENT PROGRAM DEVELOPMENT

Program Approved (AL, MN, WI, GA, OR, MO, IA, CT)	8
Reviewed in Headquarters by Permits and OGC - further action delayed by issues referred to State (MS, NV, SC, VT)	4
Submitted to Region	
- Program changes needed by the State (TN, NB, KS, IL, NY)	5
- Changes needed in MOA - Program complete (NC)	1
Draft submission received - formal submission to Region anticipated soon (HA, MI)	2
Submission awaiting finalization of amendments to 40 CFR Part 403 (PA)	1
States working on draft submission (IN, OH, DE)	3
Problems delaying State program delegation	
- Resource shortages in State (VA, CA)	2
- Other problems in State delaying development (MD, CO, WY, ND, MT, WA)	6
	32 NPDES States
States working on NPDES submissions which include pretreatment programs (WV, PR, NJ)	3
	35 States

the Municipal Construction Grants Division of the Office of Water Program operations, to day-to-day administration by the ten EPA regional offices. Table 1-11 provides a breakdown of the federal pretreatment expenditures by office since 1977.

1.6 SUMMARY

In sum, progress towards implementation of the National Pretreatment Program has been substantial. Roughly two thirds of eligible States have developed (or are close to completing development of) the capabilities necessary to control indirect dischargers in their States. One out of ten municipalities is operating (or has applied for approval to operate) a local pretreatment program with work towards program development begun at 1,147 POTWs (57 percent of all municipalities obligated to develop programs). The Federal government has issued and amended regulations for two of the thirty-four categorical industries.

In the four years since affirmation in the Clean Water Act of pretreatment as a means to control toxic water pollution and to protect POTWs, the nation has spent almost 72 million dollars to develop and carry out the 403 program (this includes all Federal expenditures plus monies spent by municipalities and states). The nation has spent almost 39 million dollars in construction grants funds for pretreatment to protect the larger investment made in overall funding of municipal treatment works.

The actual extent of controls on industrial users is, however, unclear. EPA data, summarized in Table 1-1, indicates that over 65% of the metals and 37% of the toxic organics from indirect dischargers have already been controlled. However, the analysis in Section 1.4.1 estimates that only 25 percent of the 2,000 POTWs are implementing controls on industrial users. This result is based on a study of 132 municipalities in which municipal officials were questioned about the extent to which they were controlling industrial wastes. Likewise, the results of visits to 77 POTWs indicates that electroplaters are controlling

TABLE 1-11

FEDERAL PRETREATMENT PROGRAM RESOURCE EXPENDITURES *

($ Thousands)

	FISCAL YEAR 1977	1978	1979	1980	1981	TOTAL
HQ Permits Division						
Personnel	317	317	200	200	200	1,234
Contracts		100	1,706	1,862	1,419	5,087
HQ Effluent Guidelines Division						
Personnel	273	273	273	273	273	1,365
Contracts	2,340	2,340	2,340	2,340	2,340	11,700
HQ Municipal Construction Division						
Personnel			40	40	40	120
Grants						38,952
Regional Personnel (Including all Pretreatment related personnel)			390	390	390	1,170
						59,628

CONSTRUCTION GRANTS FUNDS OBLIGATED TO POTWs AND STATES FOR PRETREATMENT ($ Thousands)

Region	I	II	III	IV	V	VI	VII	VIII	IX	X	Total for all Regions
Grant Total	2,500	11,221	4,874	1,245	9,240	3,352	2,041	331	2,348	1,800	38,952

Note: These figures have not been adjusted to 1981 dollars. Also included in the personnel figures is a $5,000 per fiscal year total travel cost estimate; no other costs were included.

* Totals for each area are:

Personnel	3,889
Contracts	16,787
Grants	38,952
Total	59,628

Source: Survey of EPA Headquarters and Regional Office Staff

50 percent of the metals they generate rather than the 65 percent indicated on Table 1-1. The analysis of toxic discharges from industry in this project is based on the data supplied by EPA. Accordingly, if EPA's estimates of the amount of pretreatment in place are, in fact, high then the extent of water quality impacts estimated in this report are low.

1.7 OVERVIEW OF THE PROJECT

1.7.1 Purpose

EPA issued amendments to the General Pretreatment Regulations on January 28, 1981, which were to have taken effect on March 13, 1981. The Agency decided that these amendments did not have "major economic consequence" and, therefore, an economic impact statement as required by Executive Order 12044, was not prepared. On January 29, 1981, President Reagan froze a number of regulations including the General Pretreatment Regulations (GPR) and postponed their effective dates. On February 17, 1981, Executive Order 12291 was issued replacing Executive Order 12044 and altering the procedural and substantive review requirements incumbent on federal agencies for new, existing and pending regulations. Executive Order 12291 was invoked on March 27, 1981, to indefinitely suspend the applicability of the GPR until a regulatory impact analysis was prepared by EPA.

The purpose of this project is to provide technical information in support of EPA's preparation of this Regulatory Impact Analysis (RIA) of the General Pretreatment Regulations.

The Office of Management and Budget has identified five elements essential to a regulatory impact analysis;

1) A statement of the need for and consequences of the regulatory action;
2) The examination of alternative approaches;

3) An analysis of benefits and costs;
4) The rationale for choosing the proposed regulatory action; and
5) The statutory authority.

JRB Associates' work over the last several months has focused on identification of key policy issues and relevant data, and the development and use of analytical techniques to assist EPA in evaluating the General Pretreatment Regulations, and preparing an RIA which fulfills OMB requirements. This report presents information collected, the analyses conducted, and significant findings of this effort. In addition, more detailed information is provided on the data and discrete analyses which support this report in an accompanying Appendix. An extensive bibliography is included in the Appendix which catalogues the numerous data sources used in this projects. Finally, a discrete computer model has been developed and is currently operational on the EPA computer which generates data valuable to the assessment of regulatory options for the control of industrial wastes at POTWs.

The following section briefly describes the approaches utilized to analyze the impacts of the National Pretreatment Program and the proposed alternatives. Far greater detail is provided in Chapter 2.

1.7.2 General Technical Approach

JRB and EPA worked together in formulating a three-phased approach to study the necessity of metal and toxic organic industrial pollution control at POTWs. Phase I consisted of an initial data collection and evaluation effort aimed at identifying all relevant data, data weaknesses, and potential application to subsequent pretreatment program analyses. In addition, intitial work was performed to develop candidate methodologies for ultimate use in the analysis phase. In Phase II of the study, techniques were designed to fill remaining data gaps, and final analytical methodologies were chosen. In Phase III, component analyses were performed and this report was prepared. This staged approach allowed a periodic reevaluation of data and methods to ensure that solutions were feasible within the time constraints of this study and tied to the central purpose of measuring the impact of the existing pretreatment program and proposed alternatives.

The elements of the analysis are described in the following subsections.

1.7.2.1 Selection of Environmental Impacts to be Analyzed

This study analyzed the central environmental problems which the existing National Pretreatment Program was intended to reduce:

- Water Pollution - which can occur as a result of improper operations and maintenance of the POTW. It can also occur as a result of indirect discharges through by-pass, pass-through and upsets.
- Sludge Contamination - which can occur if indirect dischargers fail to remove metals from their discharges. As a result, the municipality may be limited in its disposal options.
- Air Pollution - which can occur from volatilization at the POTW or through the incineration of sludges that cannot be disposed of through other means because of contamination.
- Worker Health and Safety - which can be jeopardized by indirect discharges through resulting explosions and worker exposure to toxics in the wastewater, fumes or sludge.
- Overall POTW Operation - which may be adversely affected due to upset and interference problems caused by industrial discharges.
- Groundwater Pollution which may occur due to POTW exfiltration and leachate from municipal sludge.

The determination of the relative effectiveness and cost of each pretreatment regulatory option in controlling the above problems is the principal focus of this study.

1.7.2.2 Analytical Methods

Having specified the above problems as the central issues behind the pretreatment regulatory impact analysis, it remained to be decided which measures could and should be employed to quantify the magnitude of these impacts. The availability of data and applicability of legal standards largely determined which measures were used. Almost no data existed on the volume of toxic air emissions attributable to the incineration of municpal sludges or from influent volatilization. Nor were any nationwide statistics found on the frequency of worker injuries or deaths at POTWs as a result of industrial discharges of toxic pollutants. Data inadequancies 1) forced a more qualitative, case-study evaluation of groundwater, worker health and safety, and POTW operational problems and 2) dictated the development of a mass-balance computer model to forecast water pollution, sludge contamination and air pollution impacts associated with alternative regulatory strategies.

The mass-balance computer model of a POTW system was the primary tool for quantifying the environmental benefits and costs for any alternative pretreatment program. JRB developed this mathematical model for the 2000 POTWs across the country required to implement local pretreatment programs under the General Pretreatment Regulations. The model simulates the operation of a single POTW, distributes pounds of priority pollutants from industry among POTWs to allow an assessment of water quality and sludge impacts, and allows aggregration of individual results to national or regional totals. It consists of eleven data sources, including Dun and Bradstreet industrial lists, EPA's Permit Compliance System, STORET, USGS, and EPA's NEEDS Survey, among others. The types of outputs of the model are discussed in the following subsections.

1.7.2.3 Environmental Measures

The POTW model estimates the following quantitative environmental measures for alternative pretreatment options for each of the 2000 POTWs:

PROBLEM	MEASURE
Water Pollution	Exceedances of Water Quality Criteria Violation of NPDES Permits Mass of Pollutants Volume of Pollutants Discharged Net Change in Effluent Quality
Sludge Contamination	Volume and Contamination of Municipal Sludge Volume and Contamination of Industrial Sludge
Air Pollution	Mass of Volatile Priority Pollutants Discharged to Air

Most of these measures quantify for comparison among pretreatment options, the volume of pollution reduced, the volume that continues to be discharged and the concentration of toxics in the POTW effluent and in sludges.

While measures of pollutant volume and concentration are useful indicators, they do not necessarily reflect the significance of their impacts to the environment. Therefore, the impact of the POTW effluent discharge on the concentration of toxic pollutants in the POTW receiving waters was also estimated. For these concentration estimates to be most useful, they were compared to benchmark concentration levels that indicate whether the resulting concentration represents a water quality problem. When the concentration of a toxic in the receiving stream was greater than that threshold, it was termed an "exceedance" -- an indicator of potential water quality problems.

Unfortunately, there are few well-established environmental standards in place which provide a basis for establishing the threshold for an exceedance. Only 30 States have set State water quality standards for one or more toxic organic pollutants and 29 have standards for one or more heavy metals. Efforts were made to calculate representative average values for State water quality standards for the critical parameters to fill in these considerable voids and to facilitate a national impact assessment. However, the results of this exercise were not felt to be either manageable or a better indicator of actual conditions. Moreover, very few POTWs have toxic pollutant limits in their

NPDES permits, thereby eliminating the use of these levels as thresholds (as well as the significance of permit violations to this analysis). The decision was made, therefore, to use federal water quality criteria as the benchmark for exceedances and, therefore, potential water quality problems.

As a final component to the estimation of exceedances, a significant effort was made to gather ambient water quality information on the level of toxics in receiving streams. However, this data was severely inadequate. Therefore, the water quality impacts of POTW discharges are measured as if the POTWs were discharging to pristine water, obviously not the case in the real world. To offset this assumption, this report provides a sensitivity analysis that predicts exceedances for three levels of ambient concentrations in the receiving waters.

A parallel effort was made to analyze the significance of changes in the concentration of priority pollutants in municipal sludge resulting from indirect industrial discharges. Unfortunately, few sludge disposal guidelines have yet been issued by EPA under Section 405 of the Clean Water Act or Section 4004 of the Resource Conservation and Recovery Act. The most relevant of these, the limits on cadmium in municipal sludge to be landspread, requires a knowledge of soil cation exchange capacities, and the type of crops to be cultivated, in addition to the cadmium concentration level in the sludge. This information could not be collected and analyzed in the time frame of this study. State solid waste disposal rules vary considerably as to their coverage of the numerous disposal options used by POTWs and very few contain specific limitations on pollutant concentrations in sludge. Food and Drug Administration (FDA) and the Department of Agriculture foodchain related guidance were deemed inadequate. Even regulations of foreign countries were evaluated for possible use. Compounding these regulatory difficulties, it proved impossible to develop meaningful predictors of a municipality's ability to switch between disposal methods. Costs for the same disposal option vary dramatically between cities, affected by the availability and proximity of disposal sites, agricultural land, and other site-specific factors. JRB and EPA eventually decided that given time constraints, no meaningful sludge criteria could be constructed for this study. The report makes predictions on sludge quantity and quality both for industry and municipalities but, given the lack of regulatory triggers, assumes that all industrial sludge is hazardous (although some industrial sludges are no longer classified as hazardous by EPA) and all municipal sludge is nonhazardous in calculating associated disposal costs, regardless of sludge quality improvement or degradation under the various options.

1.7.2.4 Cost Assessment

Having identified the central environmental problems to be controlled under any pretreatment program and having chosen key criteria used to measure the environmental impacts of alternative programs, it was necessary to identify where the costs of compliance would be sustained so that data could be collected and impacts estimated. The principal actors under any pretreatment strategy are industry, POTWs, States and the federal government. A decision was made to limit the cost assessment on this project to the following direct costs:

- Industrial Impacts

  Pretreatment Technology Costs
  Sludge Disposal Costs

- Municipal Impacts

  POTW Pretreatment Program Development Costs
  POTW Pretreatment Program Operational Costs
  POTW Sludge Disposal Costs

- State Impacts

  State Pretreatment Program Development Costs
  State pretreatment Program Operational Costs

- Federal Impacts

  EPA Administrative Costs
  Construction Grants for Pretreatment Program Development

The POTW Model provided treatment and sludge disposal costs. Administrative costs for municipalities, States and to the federal government were based on historical estimates and case study extrapolations.

A number of cost factors had to be excluded due to the lack of adequate data or as a result of regulatory assumptions made above. For example, municpal costs were not reduced to account for savings experienced by POTWs due to the fewer operational problems attributable to an effective pretreatment program. Sludge disposal cost savings similarly could not be passed on to cities where the improvement in sludge quality due to pretreatment facilitate use of a less expensive disposal option.

1.7.3 Limitations of This Assessment

The data collected and analyses performed in support of EPA's pretreatment regulatory impact analysis and presented in this report should provide meaningful decision-making tools and information for the ultimate resolution of the complex issues inherent to the assessment of this major regulatory program. Nonetheless, a number of caveats must be presented which place the findings in perspective.

1.7.3.1 Data Limitations

Our ability to analyze the existing pretreatment program and possible alternatives in a logical and complete manner was often hindered by the lack of available health and environmental data. Solutions were designed to overcome these data deficiencies where possible, but some gaps could not be filled in the time frame of this study. For instance, no single data source had complete data on the number and type of categorical industries discharging to individual POTWs. This information is critical for constructing the raw wasteloads entering POTWs as a result of industrial users. To surmount this inadequacy, Dun and Bradstreet computer lists were searched by SIC codes to identify the universe of categorical industries in the vicinity of a POTW. The Permit Compliance System Data Base was then used to back out direct dischargers holding NPDES permit from this total and these were assigned to the appropriate municipality according to the city name of the POTW as stated on the NEEDS Survey.

In fact, every component variable in the assessment of water quality impacts for this project required assumptions in order to achieve results. The mass and volume of discharge of priority pollutants from all IUs in an industrial category were all assumed to be the same -- equal to those of an average firm. The POTW receiving these wastes was assumed to attain average treatability levels. Perhaps the greatest frustration with data weaknesses was experienced with data on receiving stream characteristics. Stream flows were available for less than half of the stream segments on which the 2000 POTWs are sited. Ambient water quality for all eleven toxic pollutant parameters (nine metals, total toxic organics and cyanide) were almost uniformly unavailable resulting in the assumption that POTWs are discharging to pristine waters; and the unavailability of State water quality standards resulted in our use of federal water quality criteria. Most of these data limitations work to understate the magnitude of water quality violations associated with indirect industrial discharges but simply could not be avoided. As the assumptions necessary to overcome these weaknesses are uniform for all the pretreatment options evaluated, findings are still meaningful for comparative purposes. In absolute terms, however, higher water quality violations should be expected without industrial waste control than those predicted in this project.

Data inadequacies were found to be much worse for the health effects of toxic pollutants in air, groundwater and sludge, and findings could only be presented in terms of volumes and mass discharged to the environment either directly or concentrated in sludge. Thus, no final judgements could be made as to the beneficial effects of improving sludge quality by roughly 50 percent as our report predicts if the pretreatment program is implemented either in terms of reduced costs or a safer environment.

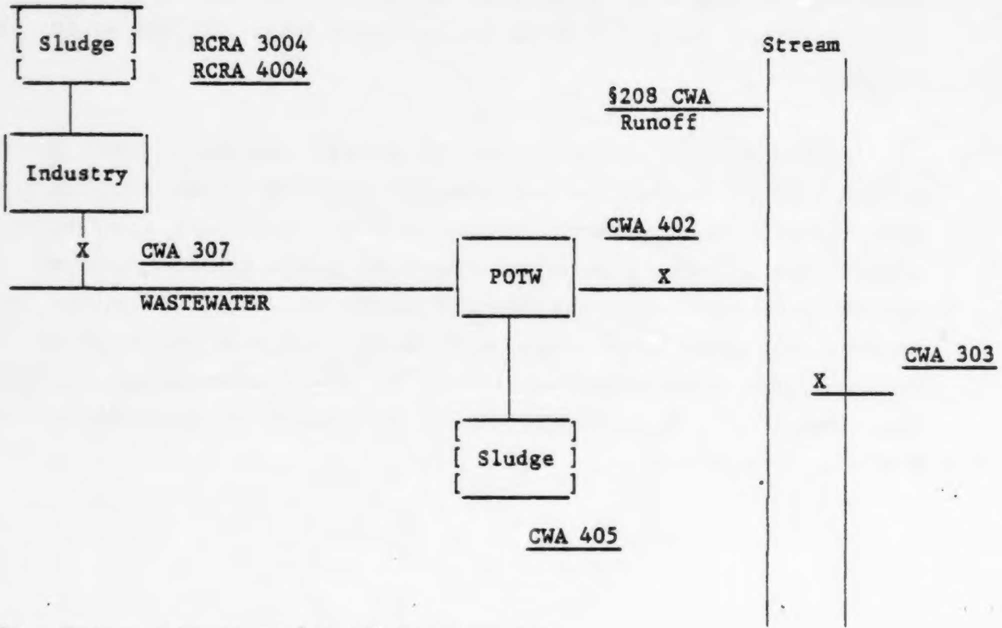
1.7.3.2 Limitations Due To Inability To Evaluate Interaction With Other Programs

Pretreatment under §307 of the Clean Water Act only regulates discharges to municipal sewers. Alone, it does not guarantee that water quality or sludge goals will be met. Moreover, its effectiveness can only be measured against the environmental standards established in other regulatory programs. As Figure 1-1 illustrates, these standards are set under §402, 208, 405 of CWA and §3004 of RCRA.

Pretreatment is, in fact, one of several regulatory tools available to control agencies to meet the environmental standards set up under the provisions which directly control environmental quality. The fact that water quality criteria are not widely accepted, municipal sludge criteria have not been set and the rules governing the classification of industrial sludge have only recently been established create major short comings in this analysis. Without the compliance boundaries established by other environmental programs, the improvements in environmental quality attributed to pretreatment are very difficult to evaluate.

Figure 1-1

WASTESTREAMS and ULTIMATE REGULATORY ENVIRONMENT


Sludge
RCRA 3004
RCRA 4004
Industry
X
CWA 307
WASTEWATER
POTW
CWA 402
X
Sludge
CWA 405
Stream
§208 CWA
Runoff
X
CWA 303

RCRA - Resource Conservation and Recovery Act

§3004	Hazardous and Non-Hazardous
§4004	Waste Disposal Critria

CWA - Clean Water Act

§307	Pretreatment Standards
§402	NPDES Permitting
§405	Municipal Sludge Disposal Guidelines
§303	Water Quality Standards
§208	Nonpoint Source Control

2. DETAILED ANALYTICAL APPROACH

This chapter discusses the criteria used in this study to measure environmental and cost impacts of industrial discharges to POTWs and the methods used to analyze these impacts.

2.1 CRITERIA FOR ASSESSING THE IMPACTS OF DISCHARGES FROM INDUSTRIAL USERS

Industrial wastes can cause a variety of problems at POTWs. The most direct impact is on the operation of the POTW itself. The generation of contaminated municipal sludge and the discharge of partially treated wastewaters to receiving bodies are additional impacts that can, in many instances, be tied to industry. Additionally, groundwater can be contaminated by leachate from landfills used to dispose of POTW sludges and agricultural lands may be contaminated by direct application of municipal sludges. Further, the atmosphere in the vicinity of municipal treatment plants can become contaminated from toxics which volatilize, affecting not only the health of POTW workers but also those living and working near these facilities. This section describes the criteria used in this analysis to define and measure the impact of industrial dischargers on POTW operations and environmental quality.

This project is designed to analyze impacts which result from the indirect discharge of industrial wastes. When possible, these impacts are measured quantitatively. However, some impacts cannot be quantified from the data available. In these cases the extent of the impacts are described and examples of the impacts from case study reports are used to document their occurrence. The impacts are organized into six categories: pass-through and water quality, interference and upsets, sludge contamination, worker health and safety, air pollution and ground water pollution. The following section introduces each of the impacts with a preliminary overview of the data sources and their findings, and the methods and criteria used to measure these impacts.

2.1.1 Pass-Through and Water Quality

Some pollutants pass-through a POTW untreated or partially treated to the receiving waterbody. The most common reasons for pass-through are that:

- POTWs are not designed for the removal of certain pollutants.
- Interference of the POTW system occurs which reduces the POTWs treatment capability
- Slug loadings, hydraulic overload and operator errors upset plant operations.

The pass-through of pollutants has no significant impact on the POTW's collection and treatment system. However, pollutants which pass-through can degrade the quality of the receiving waters. This degradation may violate water quality standards thereby restricting the use of the waterbody and potentially affecting the health of humans and aquatic organisms. For example, a contaminated river may no longer be adequate as a drinking water supply or for recreational purposes.

The most direct way to measure the extent of pass-through at POTWs would be to count NPDES permit violations. However, few POTW permits include toxic limits. For most POTWs in the U.S., NPDES discharge limits have been established for conventional pollutants based on technological capabilities and reflect a level of secondary treatment as required by the Clean Water Act (CWA). Many POTWs have NPDES limits which are more stringent than secondary treatment. These limits are usually set to protect the quality of receiving waters rather than solely to meet a specific technology-based removal efficiency. Limits established for this purpose are said to be "water quality limited." Since toxic pollutants are not addressed in the CWA definition of secondary treatment, toxic pollutant limits incorporated into POTW permits are generally water-quality based.

In general, data on NPDES permit violations exist for conventional pollutants [biochemical oxygen demand (BOD), suspended solids (SS)]. However, few POTW permits contain water-quality based limits for toxic pollutants. Even in those case where limits have been set, there is only limited monitoring data for toxic pollutants in POTW effluents. Accordingly, NPDES permit violations are not currently a good indicator of toxic water quality problems.

Because of the limited number of POTW permits with toxic limits and insufficient monitoring data for toxic pollutants, our approach to assessing water quality impacts from POTW discharges was to estimate the amount of pass-through at each POTW using a mathematical model. This model was relied upon to predict the quantity and quality of toxic discharges from each POTW. Using measured stream flow data, the model predicts the concentration of toxic pollutants in the receiving water body contributed by POTWs.

These predicted toxic pollutant concentrations from the model can be compared to environmental standards as a way to measure water quality. If the standard is exceeded, than a water quality problem has been identified. The question is what environmental standard to use. The comparison should be consistent with the way water quality based NPDES permit limits are established. Generally, State water pollution control agencies set these limits as part of a water quality management process as outlined below.

- First, the use of the water body is designated by the State agency (e.g., water supply, contact recreation).
- Second, the State derives water quality standards to protect the designated use. The basis for State standards are the National Water Quality Criteria which EPA is developing for toxic pollutants. Water quality standards can differ from National criteria because of site-specific chemical, physical and biological conditions.
- Third, NPDES permit limits are set for each point source and other water management plans are implemented to ensure that water quality standards are met in the receiving body.

Clearly, the most appropriate way to evaluate water quality impacts is to directly compare modeled effluent concentrations to established State water quality standards. However, few State water quality standards have been established to date. Table 2-1 lists the values of State standards for metals. Those with more stringent values are reported separately from the less stringent values. In addition, the number of States with standards for each parameter is listed at the bottom of the table. The greatest number of standards have been established for lead, cyanide, and cadmium. However, only 16 States have values for these pollutants. Only six States have standards for silver. Since we were interested in comparing ambient water quality for eleven toxic parameters for all 50 States, the State water quality standards are too limited for determining the National water quality impacts of industrial users.

The next best benchmark for counting water quality problems caused by POTWs are the National Water Quality Criteria themselves. The use of national criteria enables the analysis to address all toxics of interest and also conform to the national scope of this study. Accordingly, these criteria were adopted in this project. There are two kinds of National criteria: (1) concentrations estimated to be protective of aquatic life and wildlife; and (2) concentrations relevant to the protection of human health. They are prepared according to the procedures in the revised guidelines issued in 45 FR 79318 (November 28, 1980). These criteria are simply the best estimate of the concentration-effect relationship informed scientists are able to make, based on the information from published studies. Specific numerical concentration limitations are established for most pollutants. When data limitations preclude a numerical determination, the criteria is given qualitatively.

EPA develops both chronic (long-term) and acute (short-term) water quality criteria. In this analysis, chronic toxicity criteria for human health and aquatic organisms are used along with average stream flows, to measure water quality impacts of the POTW effluents computed by the model. The criteria

TABLE 2-1

STATES WITH STRICTER AQUATIC HEALTH STANDARDS THAN NATIONAL CRITERIA

(mg/1)

State	CN	Ag	Cd	Cr	Cu	Hg	Ni	Pb	Zn
California									
Colorado					.005	.00005	.05		
Florida		.00005							
Indiana						.00005			
Kentucky						.00005			.01 ($96LC_{50}$)
Missouri				.01		.00005			
Montana*					.001				
N. Carolina						.00005			
Ohio*									
Oregon*				.02	.005				.01
Pennsylvania							.01 ($96LC_{50}$)		.01 ($96LC_{50}$)
Utah						.00005			.005
Virginia						.00005	.01 ($96LC_{50}$)		.01 ($96LC_{50}$)

TABLE 2-1 (Continued)

STATES WITH EQUIVALENT OR LESS STRINGENT AQUATIC HEALTH STANDARDS THAN NATIONAL CRITERIA

(mg/l)

State	CN	Ag	Cd	Cr	Cu	Hg	Ni	Pb	Zn
Arizona	.1	.05	.01	.05	.05	.005		.05	
California*									
Colorado	.005	.001	.0004					.004	
Florida	.005		.0008	.05	.5	.0002	.1	.05	
Illinois**	.1	.005	.01	.3	1.0	.0005	1.0	.1	1.0
Indiana	.01			.05				.5	
Iowa	.005	.05	.0012	.05		.05	.1	1.0	
Kentucky	.005		.004	.1	.01 (96LC_{50})		.01 (96LC_{50})		
Missouri	.005		.012		.02		.1	.05	.1
Montana*		.01		.05				.05	.1
Nebraska*	.005								
Nevada*				.05					
New Jersey		.05	.01	.05		.005		.05	
New York+	.1		.3		.2				.3
N. Carolina			.004				.1	.03	
N. Dakota			.01			.002			
Ohio*									
Oregon*	.005		.003					.05	
Pennsylvania	.005		.05		.1			.05	
Tennessee	.1 (96LC_{50})		.1 (96LC_{50})	.1 (96LC_{50})	.1 (96LC_{50})	.1 (96LC_{50})		.1 (96LC_{50})	.1 (96LC_{50})
Utah	.005	.05	.004	.1	.01			.05	
Virginia	.005			.1	.1 (96LC_{50})			.1 (96LC_{50})	
W. Virginia	.025	.05	.01	.05	.1 (96LC_{50})	.1 (96LC_{50})		.05	.1 (96LC_{50})
Total No. States with Standards	16	9	16	15	14	15	9	16	11

* At certain discharge points

** Have State criteria for all 9 pollutants

+ For fresh water discharge

were chosen over acute toxicity criteria and 7-day/10-year low flow conditions because the POTW model incorporates yearly average data. It does not predict short-term events because industrial effluent and POTW influent data was most complete and readily available as annual averages. Therefore, chronic water quality criteria are the appropriate standards in this analysis. A shortcoming of this analysis is that all regulators and scientists do not agree that the National Water Quality Criteria are set at the optimal level. Some argue that the data base used to establish the standards is flawed; others criticize the methods used by EPA to analyze the data. Nonetheless, these values are the best available for a national assessment of water quality impacts. At a minimum, they enable the relative impacts among pretreatment alternatives to be compared.

In addition to pass-through, POTWs can also affect water quality through by-passing of raw wastes directly to the receiving body. Causes for by-pass include (1) extensive infiltration, (2) storm water runoff, and (3) operational problems. Periodic by-pass can degrade water quality. Data from EPA's Operation and Maintenance File can and is used in this study to estimate the extent of bypass at POTWs.

As a final component of this water quality equation, a signficant effort was made to gather ambient water quality information on the level of toxics in receiving streams. However, this data was severely inadequate. Therefore, the water quality impacts of POTW discharges are measured as if the POTWs were discharging to pristine water, obviously not the case in the real world. To offset this assumption, the model was used to predict exceedances of three increments of the applicable water quality criteria (for 25, 50 and 100 percent of the water quality criteria) rather than actual water quality violations.

2.1.2 Interference and Upsets

Interference is defined as the inhibition or disruption of the POTW, its treatment processes or operations, its sludge processes, its sludge use or disposal. Interference may be caused by high volumes or concentrations of pollutants which can adversely impact the proper operation of a POTW, thus causing it to treat its wastes less efficiently than normal. Conventional pollutants are the principle cause for interference problems. The most common types of interference are:

- Corrosion of POTW equipment and materials due to low pH.
- Obstruction of flow or interference with operations due to solid or viscous pollutants.
- Creation of a fire or explosion due to discharge of volatile materials
- Unit process upsets caused by the discharge of any pollutant (including BOD and SS).
- Inhibition of biological activity or increase in POTW influent temperature due to heat discharges.
- Inhibition of biological activity due to toxic pollutants.

A way to assess the impact of interference is by examining operation and maintenance problems at POTWs as well as increased POTW expenditures, and additional POTW protection equipment attributable to interference. Documentation of the number, type, and extent of interference is not kept by all POTWs. Although precise measures of industrial-related interference problems are not available for all POTWs, quantitative and qualitative information does exist for some. Our method of analyzing interference problems is based on statistical summaries of data on interference from EPA's Operation and Maintenance File, the results from field visits to 77 POTWs conducted by JRB, and from case study findings reported in the literature. However, pass-through due to interference is not incorporated into the POTW model. As a result, the model only predicts persistent water quality effects. Chapter 3 discusses this in greater detail. Actual impacts would be higher.

There are many causes of POTW upsets, including inadequate design and plant obsolescence. However, industrial waste has been identified by POTWs as a major cause of O&M problems and poor plant performance. Upsets from industrial waste can have a number of different adverse effects on a POTW including:

- Upsets from slug discharges of toxic pollutants (e.g., unexpected batch dumps);
- Digester upsets which can lead to reduced POTW efficiency;
- Upset from slug discharges of conventional pollutants (high BOD).

Upsets are, again, not addressed by the computer model and are another contributing source of water quality violations. The extent of these impacts are addressed in Chapter 3.

2.1.3 Sludge Contamination

Many toxic pollutants, especially metals, are removed from the influent to a POTW and are deposited in the POTW's sludge. This removal is incidental and occurs through normal secondary treatment. The contamination of the POTW sludge with toxic pollutants can limit sludge disposal alternatives as follows:

- Land spreading of sludge may be restricted because toxic pollutants can result in uptake into crops and into the human food chain or cause surface/ground water contamination.
- Storage of sludge on land may be restricted for the above reasons.
- Sludge may not be permitted in conventional landfills due to the potential contamination of ground water as a result of leaching.
- Selling sludge as a soil conditioner may not be an option due to toxics contamination.
- Unknown environmental effects of toxics on municipal sludges has led some State agencies to restrict land disposal of these sludges.

Sometimes, POTWs with potential contamination problems conduct sludge sampling and analysis. This data is also available as a result of several EPA studies which included special analyses of POTW sludges for industrial contaminants. The literature, EPA studies, and case studies provide further information on disposal, ground water, and surface water problems caused by contaminated POTW sludge. This information is an important part of our analysis of sludge contamination.

As in the case of pass-through, quantitative sludge contamination and disposal data do not exist for all POTWs. Since improved municipal sludge quality is an important aspect of a pretreatment program, quantifying this data was necessary for our analysis. Again, the mathematical model was used as a predictive tool. Based on actual data for selected POTWs, the model was used to estimate the amount of sludge generated, pollutant concentrations, disposal methods, and related costs. The model was used to estimate both POTW sludge and sludges generated by industrial pretreatment systems.

A parallel effort was made to impose meaningful regulatory limits on priority pollutants in municipal sludge resulting from indirect industrial discharges. Few sludge disposal guidelines have yet been issued by EPA under {405 of the Clean Water Act and Section 4004 of Resource Conservation and Recovery Act. State solid waste disposal rules vary considerably as to their coverage of the numerous disposal options used by POTWs and very few contain specific limitations on pollutant concentrations in sludge. Food and Drug Administration (FDA) and the Department of Agriculture food chain-related guidance were deemed inadequate. Even regulations of foreign countries were evaluated for possible use. JRB and EPA eventually decided that given time constraints, no meaningful sludge criteria could be constructed for this study. The report makes predictions on sludge quantity and quality both for industry and municipalities but, given the lack of regulatory triggers, assumes that all industrial sludge is hazardous and all municipal sludge is non-hazardous in calculating associated disposal costs, regardless of sludge quality improvement or degradation under the various options.

2.1.4 Worker Health and Safety

POTW workers can be exposed to chemical substances caused by or related to the discharge of industrial effluents. The principal concerns are:

- Exposure to airborne chemical contaminants.

- Skin contact with industrial effluents.
- Handling of strong acids and bases used as pH control reagents for wastestreams with variable pH.
- Explosions caused by industrial wastes in the POTW collection or treatment system.

The toxicological properties and exposure criteria are known for many toxic industrial pollutants. However, only a limited amount of data exist related to airborne industrial contaminants in the vicinity of POTWs. The limited data available were collected in this project and compared to the toxicological criteria. The analysis of worker health/safety focuses on case studies of problems at various POTWs.

2.1.5 Air Pollution

Air pollution problems from the incineration or pyrolysis of municipal sludge is assessed qualitatively in this analysis. Although some evidence of adverse health effects and violation of air emission standards are found in the literature, there is not enough information to perform a quantitative assessment. The results of the analysis of air pollution problems from municipal sludge incineration is discussed in Chapter 3.

2.1.6 Ground Water

Ground water problems from indirect discharges is handled qualitatively in this analysis. Although the literature contains evidence of exfiltration from sewer pipes, the data does not lend itself to incorporation into the modeling efforts. The results from this literaure search are summarized in Chapter 3.

2.2 METHODS OF ANALYSIS

Two types of analyses were performed during this project. The first was an analysis of available information to assess four of the six impacts described above; (1) interference and upsets, (2) worker health and safety, (3) air pollution, and (4) groundwater. The second type of analysis was the development and use of the mathematical model to examine the remaining two impacts, pass-through and water quality, and sludge generation. Data from the first analysis were also used in the modelling effort. The two analyses are described below.

2.2.1 Analysis of Data Bases Depicting POTW Operations

Seven data sources were used in this study to develop profiles of POTW operations. These data sources provide the means to carry out quantitative and qualitative analyses of actual conditions encountered at municipal facilities. The purpose of these analyses is to determine:

- The frequency of occurrence of operational problems.
- Persistent operational problems which are linked to industrial discharges and lead to environmental degradation.
- The impact of pretreatment on POTW effluents before and after implementation of pretreatment.
- The motivation for the development of pretreatment programs by municipalities.
- Other information regarding specific POTW operations and environmental conditions and problems.

The data sources presented in this section are used in Chapter 3 to document and exemplify industrial discharges and treatment facility operations. Complete analyses of each data source are provided in Appendix B.

2.2.1.1 40 POTW Study

The Effluent Guidelines Division (EGD) of EPA carried out a two-year study at 40 POTWs to determine the fate and occurrence of both conventional pollutants and the 129 priority pollutants. The 40 POTWs selected for study were distributed according to geographic location, average daily flow, percentage industrial flow, and the treatment processes utilized. The study represents a profile of well operated POTWs receiving more than 5 mgd average daily flow which are required to implement local pretreatment programs.

At each of the 40 POTWs, an intensive, week long priority pollutant sampling and analysis program was conducted of various operations. Sampling points included the POTW influent, secondary effluent, primary and/or tertiary effluent, primary or combined sludge, and secondary sludge. Six 24-hour samples were normally collected at each POTW.

Detailed results of this analysis are presented in Appendix B-4.

2.2.1.2 EPA 4-City Study

During 1978 and 1979 the Monitoring and Data Support Division of EPA conducted a source sampling survey of 4 POTW collection systems. Sampling in all 4 cities was conducted in interceptors from domestic, commercial, and industrial users, and at the POTW influent. The industrial component of this study was not used in the RIA because the four collection systems did not include a sufficient variety of EPA's categorical industries. However, the domestic and commercial results were used in the model as a second measure of nonindustrial contribution. It is important to note that two of the four cities in this study were the two plants from the 40 POTW study that had little industry. All four cities were included in the 40 POTW sampling.

2.2.1.3 132 Study

In 1981, the EPA Office of Water Enforcement engaged in a statistical assessment of selected municipalities to estimate the progress made in controlling industrial waste discharges to POTWs. The analysis included a determination of the control programs developed through local initiatives, and those developed in response to the requirements of the National Pretreatment Program. The assessment of local control programs consisted of a study of 132 randomly selected municipal authorities, operating 294 plants made in conjunction with a technical assessment project managed by JRB. The data sought in the study were:

- General facility data,
- Industrial waste survey information,
- Industrial users information and regulated industries,
- Legal authority,
- Formal pretreatment programs, including motivation for program development, sewer ordinance limits, and monitoring,
- Industrial controls,
- POTW NPDES permit information, including permit violations.

The POTWs included in the assessment were chosen using a random number generator and proved to be a statistically representative sample of the 2,000 POTWs required to develop local pretreatment programs for key measurements. Figures 2-1 to 2-3 present a graphical comparison of the 132 data base with the complete 2,000 POTW data base for three important measurements:

- Total Flow
- Percent Industrial Flow
- Number of Metal Finishers and Percent Industrial Flow

These figures indicate that the 132 subgroup have similar trends as the entire population of 2,000 POTWs.

The results of this analysis are presented in Appendix B-2.

2.2.1.4 The Operation and Maintenance Data Base (O&M)

The Operation and Maintenance (O&M) data base was compiled and computerized by EPA from reports of POTW inspections conducted by EPA and the States. The

Figure 2-1 COMPARISON OF 132 POTW SUBGROUP TO 2000 POTW
NUMBER POTWS vs. POTW EXISTING FLOW

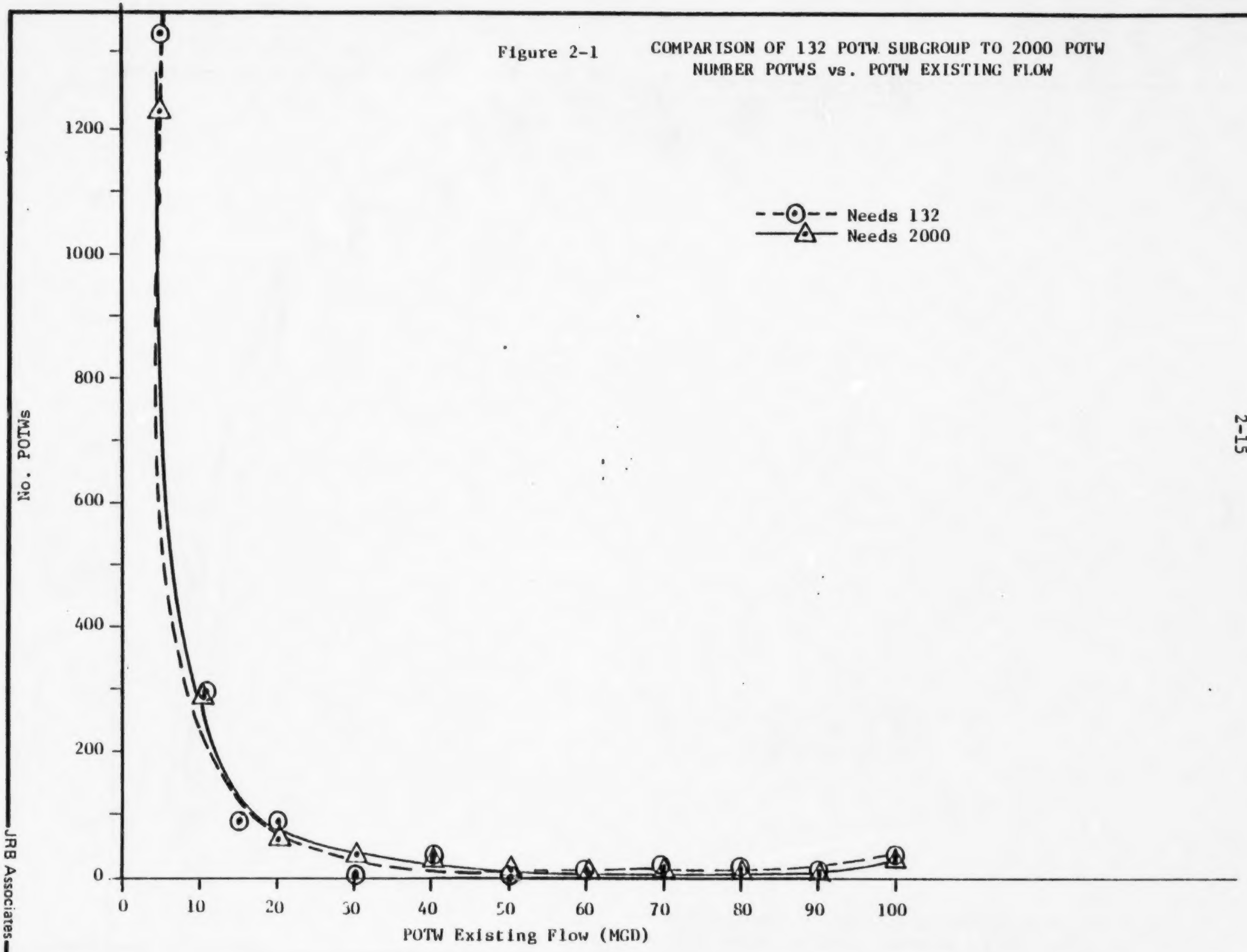


Figure 2-2. COMPARISON OF 132 POTW SUBGROUP TO 2000 POTW NUMBER POTWS vs. PERCENT INDUSTRIAL FLOW

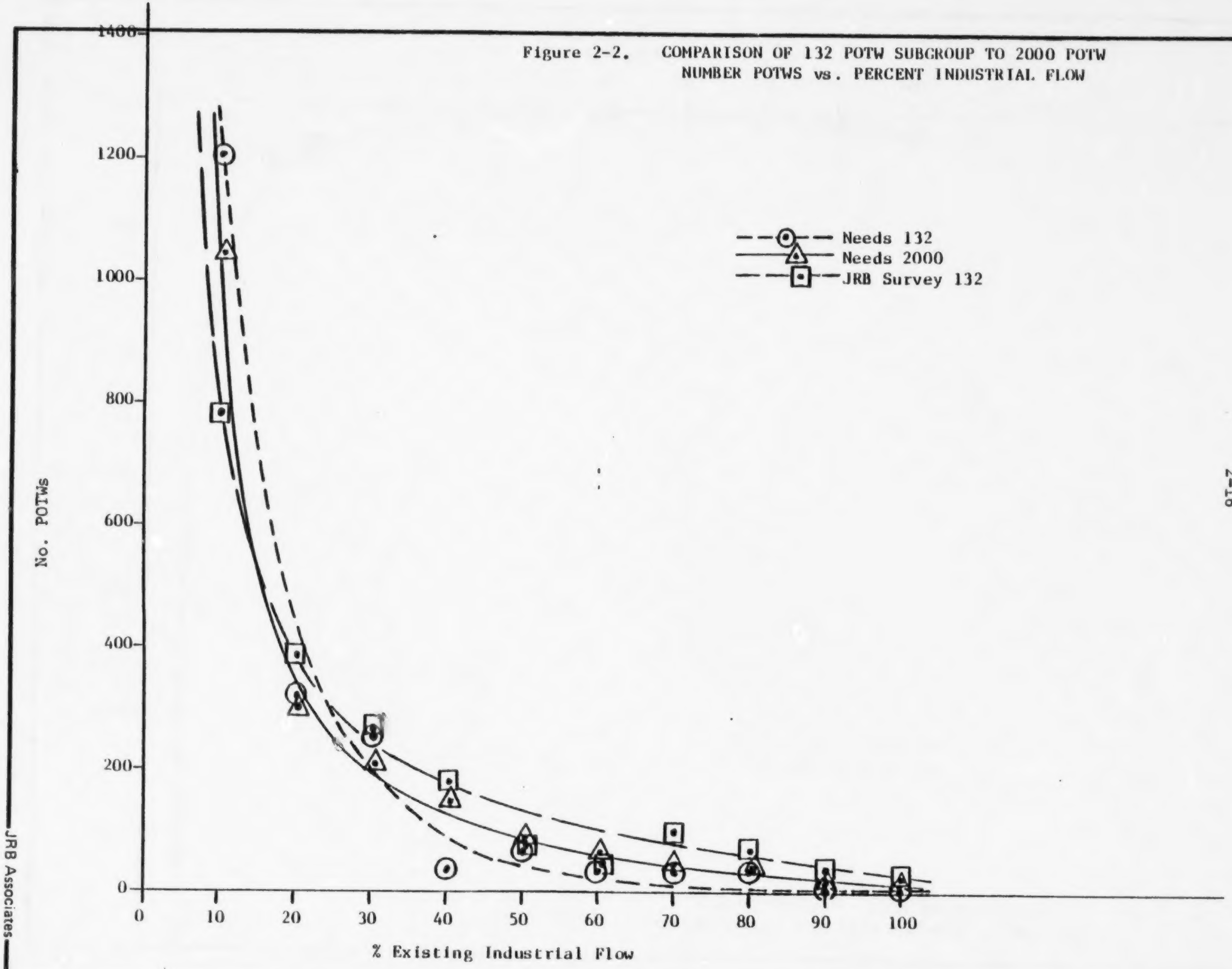
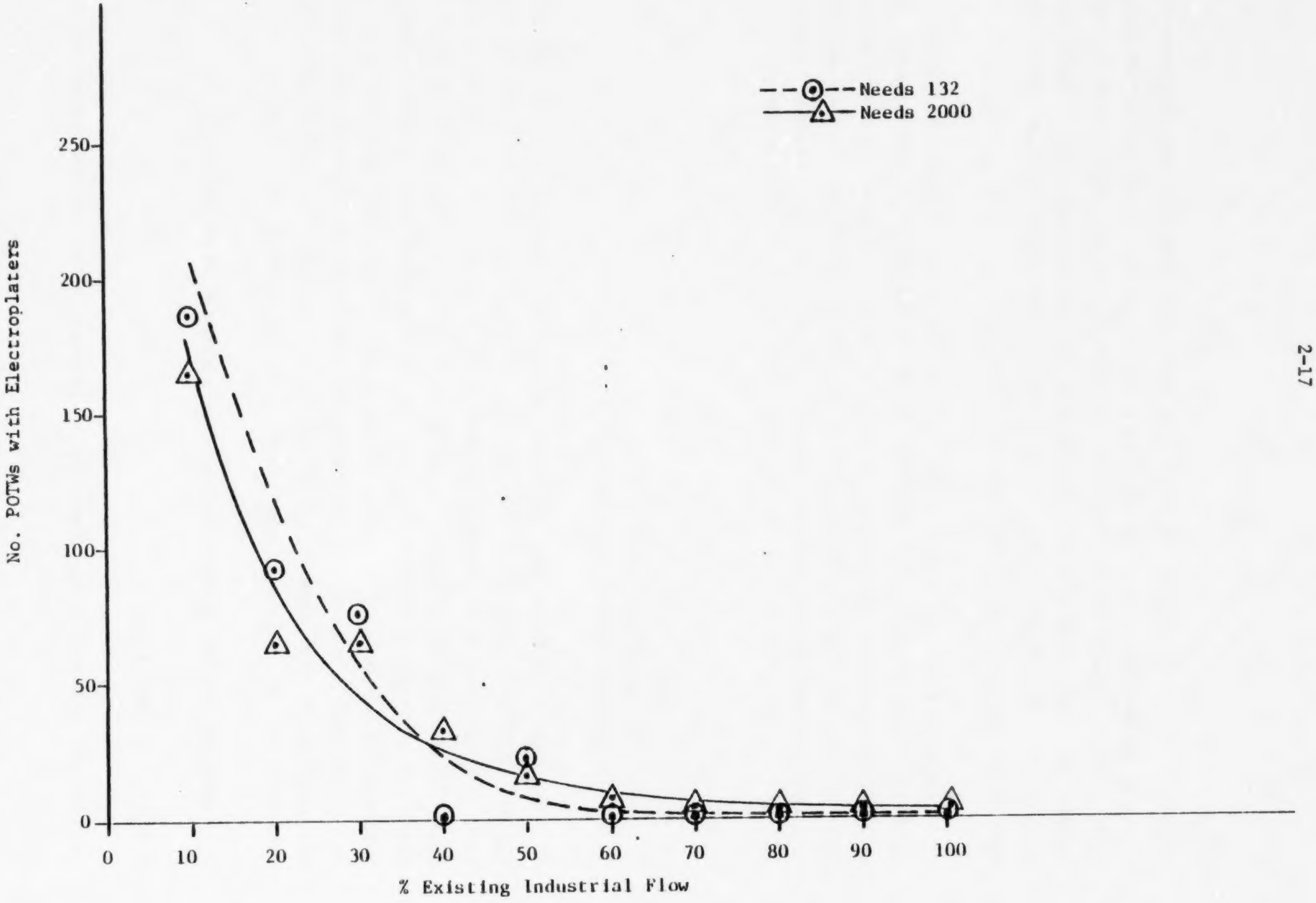


Figure 2-3. COMPARISON OF 132 POTW SUBGROUP TO 2000 POTW
NUMBER OF POTWS WITH ELECTROPLATERS vs. PERCENT INDUSTRIAL FLOW



purpose of these inspections is to check on POTW compliance with the requirements of NPDES permits and Construction Grants and to assess staffing and training needs. These inspections are required by §210 of the Clean Water Act and the results are summarized by EPA and reported to Congress annually. Inspection frequency is determined by the requirements of the State and the degree and type of problems encountered at each facility.

Information is collected on EPA Form 7500-5 (4-72), "Report on Operation and Maintenance of Wastewater Treatment Plant." Inspectors obtain information to complete the form from on-site reviews of facility records, such as laboratory records, maintenance records, and daily logs of operation, and by examining equipment, interviewing staff, and observing procedures. Four generic categories of data addressed by the inspections are represented in the data base:

- Identification information
- Facility data
- Pollution load data
- Facility operations assessments

The O&M inspections are performed at the discretion of State and EPA Regional offices. Generally they contain reports of upset and by-pass and their duration, as well as NPDES permit violations and identification of the causes of operational problems including industrial sources. Complete inspections and assessments are usually made if problems have been reported, while more routine inspections are made if no problems have been encountered. In the latter case, only an overall assessment of plant operation is performed, and portions of the inspection form related to problems are left blank. The data used in the analysis come from 1500 inspections conducted in 1980.

Detailed results of this analysis are presented in Appendix B-1.

2.2.1.5 77 POTW Study

The 77 POTW Study was conducted by JRB Associates and subcontractors in

1979 to 1980. Under this study, technical assistance was provided to 77 POTWs with design flow less than 5 mgd. Candidate POTWs were selected after screening from a list identified by EPA Regional Offices and NPDES States. The POTWs covered in this assistance program were distributed over 22 States and nine of the ten EPA Regions. A report was prepared on each POTW, describing plant operations, performance data, and operating conditions and problems. Major nondomestic users of each POTW were visited to determine the quantity and origin of pollutants entering the POTW. An analysis of these data was performed to examine:

- POTW operational problems,
- Distribution of categorical and noncategorical industries discharging to these POTWs,
- The impact of specific industries discharges to these POTWs, and
- Industrial discharge limit setting and monitoring/enforcement practices.

The results of this analysis are presented in Appendix B-3.

2.2.1.6 Literature Search Case Study

JRB compiled data on nineteen municipalities with industrial waste control programs to assess differences in POTW operating parameters before and after program initiation. The sources of information included academic and trade literature, published reports and papers by the municipalities and EPA, and a telephone survey of nine POTWs conducted by JRB. Eight municipalities had sufficient documentation regarding pretreatment to be included as an information source for this study. The eight municipalities are representative of a variety of population sizes and service areas, average daily flows, types of industries, and quantities of industrial flow.

The case study analysis is presented in Appendix B-5.

2.2.1.7 NEED's Survey

Since 1969, EPA has assessed POTW construction requirements through the NEED's Survey. The results of the survey are summarized and computerized by EPA and used for appropriating Construction Grant funds to the States. The 1980 survey includes estimates of the present needs to fulfill NPDES requirements, and cost predictions to meet the 1990 needs. Various means were used by EPA to make these estimates, such as engineering estimates, comparison with previous costs, EPA cost estimating procedures, and rough estimates. The 1990 predictions are based on projections of future populations and the present value of future construction costs.

The data for the 1980 NEED's Survey was developed by updating the 1978 NEED's Survey on a facility-by-facility basis. Information from previous NEED's Surveys is recorded on the NEED's Survey form and updated using information in:

- 1978 NEED's Survey
- Regional files
    - NPDES permits and applications
    - Construction grants
    - O&M data
    - Facility and/or regional plan (201 and 208)
    - State water quality files
- State and locally supplied data

Five generic data categories are represented in the survey:

- Identification information
- Pollution load data
- Pollution control data
- Facility status information
- Construction needs information.

All communities with populations greater than 10,000, and all communities within Standard Metropolitan Statistical Areas (SMSAs), are included in the survey. States decide how many of their communities with populations of less than 10,000 would also be surveyed, but at least 20 percent of these communities are included. Twenty-nine States and territories included 100 percent sampling of the small communities. All 2,000 municipalities subject to the General Pretreatment Regulations are included in the NEEDs Survey.

2.2.1.8 Permit Compliance System

The Permit Compliance System (PCS) is designed to track construction and monitoring events detailed in NPDES permits. Inspections of POTW facilities are made by the State or EPA Region to verify that the construction requirements scheduled in the permits have been completed.

The PCS, a computerized system, contains no technical data. Regional EPA offices keep the technical data separately in NPDES files which are generally not computerized. These data include pollution loadings, waste treatment components, and proposed construction information, and discharge monitoring reports, which contain the results of periodic self-monitoring required in each NPDES permit. Although this technical information is not entered into PCS, portions are extracted and compiled in the NEED's Survey data base.

The information contained in PCS is entirely descriptive and used for enforcement and compliance purposes. It is continually updated by EPA as a current source of descriptive information on compliance. In this project, PCS data is used soley to estimate the number of industrial users discharging directly to receiving water bodies.

2.2.2 Summary of Information from Data Bases

The data bases that measure POTW problems tend to verify that common problems exist at POTWs. Many of the problems are national in scope and cover plants with a full range of flow and industrial contributors. The following discussion details some of the findings from the major data bases. These findings are presented here in order to highlight the generic problems common to POTWs. In Chapter 3 of this report, these data bases are further analyzed as part of our evaluation of industrial impacts on POTWs.

O&M and Process Upsets

A high percentage of O&M and process upset problems at POTWs are associated with nondomestic (industrial) flows entering the POTW. From a review of the O&M data base and the 77 POTW visits, it can be concluded that industrial waste control will reduce the O&M and process upsets and improve POTW operation.

- Approximately 79 percent of the POTWs with O&M problems receive industrial wastes and are of a design capacity less than 5 mgd (O&M Data Base).
- Over 70 percent of POTWs that report receiving industrial wastes cite O&M problems associated with their industrial flow (O&M Data Base).
- Of POTWs with overloads, 77 percent report hydraulic overload problems and 42 percent report organic overload problems (O&M Data Base).
- O&M problems associated with industrial waste and O&M problems associated with sludge handling and processing are the most frequenctly reported problems other than plant obsolescence (O&M Data Base).
- The most commonly listed problem industries for POTWS $\leq$ 5 mgd are: food, electroplating, mechanical products, and textiles (77 POTW Study).

Permit Problems

A high percentage of POTWs violate their NPDES permit. For most POTWs, NPDES permits include limits on conventional pollutants only. The data presented in these analyses and summarized below indicate that industrial users are signficant contributors to POTW permit problems.

- More than 60 percent of the POTWs in the O&M data base that report O&M problems associated with industrial wastes violate their NPDES permit.

- Of the POTWs in the 77 POTW data base with permit violations, 65 percent of the operators at plants with permit violations attributed those violations to industrial discharges.
- Almost 70 percent of all POTWs violate their NPDES permit with approximately 50 percent of them in violation 10 percent or more of the time (132 POTW Study).
- Approximately 80 percent of all permits address only conventional pollutants with 30-40 percent of current permits having been issued prior to 1977 (132 POTW Study).
- Approximately 50 percent of the POTWs have some level of control (ordinance, permit, etc.) on all industrial users in their system, but approximately 70 percent do not monitor industries on a regular basis (132 POTW Study).

Sludge Problems

The multiple data base analyses indicate that sludge contamination is usually associated with the concentration of metals in the POTW sludge. As more POTWs select land-based disposal options, metal concentrations in POTW sludges will become a more serious concern and will need to be decreased prior to sludge disposal.

- Heavy metals removed at POTWs are incorporated into the sludge of the POTWs (40 POTW Study).
- Nearly all of the POTWs in the O&M data base that were evaluated for sludge problems reported dissatisfaction with their sludge disposal practices and/or costs.
- Of the POTWs in the 77 POTW data base, 87 percent report sludge contamination contributed by industrial wastes.
- The 77 POTW data base indicates that 30 percent of the POTWs have not sampled their sludge.

Pass-Through, By-pass and Combined Sewer Overflow (CSO) Problems

The data available from the literature and other studies are insufficient for an analysis of pass-through of toxic pollutants. In by-pass situations some pollutants are discharged into the receiving waters untreated. The O&M data base yields the following:

- Approximately 35 percent of the POTWs bypass monthly for varying time periods of up to 24 hours per month (O&M Data Base).
- The highest reported instances of bypass occur in Regions II and V which are heavily industrialized. The potential exists for signficant industrial pollution due to bypassing in these regions (O&M Data Base).
- The 40 POTW study found increased heavy metal concentrations in combined sewer systems due to wet conditions. This may be due to flushing of metals that settle during dry conditions.

General

POTWs have operational problems that are influenced by the industrial flows entering their systems. A number of POTWs do not report industrial flows because they do not know the volume. However, they do report industrial wastes as contributors to their O&M, sludge and permit problems.

- In the 40 POTW Study, industry was found to be the major contributor of the priority pollutants to POTWs. Variations in priority pollutant concentrations can be attributed to the types and sizes of industries discharging into the POTW.
- Approximately 15 organics, 8 heavy metals, and cyanide are normally found in POTW influent (40 POTW Study).
- A number of POTWs report O&M problems due to industrial wastes but do not know the industrial flow contributors into their facility (O&M Data Base).
- POTWs meeting secondary treatment requirements also remove priority pollutants. Generally, these POTWs remove 70-80 percent or more of the heavy metals, 80 percent of the total volatile organics, and 70 percent of the total acid-base-neutral organic pollutants (40 POTW Study).

- Sixty-eight (68) percent of the POTWs do not monitor their industrial users or enforce their industrial requirements on a regular basis (at least once per year); and of the remaining 32 percent that do monitor, only 12 percent monitor metals and 1 percent monitor for toxics (132 POTW Study).

- POTWs that have existing pretreatment programs have lower concentrations of priority pollutants in the POTW influent and effluent. Based on the 40 POTW Study, for example, total metals were 28 percent higher in the influents of POTWs that did not have a pretreatment program. This trend carried through to the acid-base-neutrals which were 76 percent higher in the influent; and the volatile organic priority pollutants which were 315 percent higher.

2.2.3 POTW Modeling Effort

The data sources examined above are valuable to assess the general degree and extent of environmental, health and cost impacts of pollution from indirect dischargers. However, they are insufficient to adequately measure these impacts for alternative pretreatment programs. Moreover, there is little actual data that precisely or systematically relates indirect discharges of toxic pollutants to environmental effects such as industrial sludge quality and quantity, POTW influent and effluent quality, water quality impacts on receiving streams and pretreatment related costs. To provide EPA with a precise decision-making tool, JRB developed a mathematical model of a POTW system to help quantify these environmental impacts and costs of pretreatment program alternatives at individual POTWs.

To measure water pollution and sludge contamination, the discharge of eleven pollutant parameters -- nine heavy metals, cyanide, and total toxic organics -- were quantified. These choices once again required balancing of what was available with what would be most meaningful for the analysis of toxics control at POTWs. To provide a comparative baseline, volumes and mass of discharges for silver, arsenic, cadmium, chronium, copper, mercury, nickel, lead, zinc, cyanide and total organics released into the water or concentrated in sludge were calculated. For obvious reasons, only volatile toxic organics were measured in air emissions.

The resulting information on total mass of priority pollutants released to the environment under each regulatory strategy is used in Chapter 4 to compare the costs and effectiveness of alternative pretreatment programs. The modeling effort was computerized because:

- It would facilitate data input from sources that were already computerized (e.g. STORET, NEEDs Survey, D&B etc.) and would quickly handle the sheer magnitude of the input data required to thoroughly simulate the interactions of industry, the POTW and the environment.
- It would allow a microanalysis for a large number of POTW systems, providing a better basis for analyzing national impacts.
- It could easily perform the number of simulation runs necessary to analyze the sensitivity of the key assumptions made in the project.
- It would permit a precise analysis that includes all of the 2000 POTWs for which data could be obtained.
- It would be easy to make modifications and changes in assumptions or data elements in order to rapidly test additional alternatives.

The model can calculate cost and environmental results at each of the 2000 POTWs subject to the General Pretreatment Program and aggregate national totals of these impacts for comparison. At the time of this report, some data elements were lacking for all 2,000 POTWs. For example, 1,583 POTWs discharge to receiving streams, however, stream flow data was available for only 703 POTWs. Brief details of the model development are provided below. Appendix C provides a thorough description of the model.

2.2.3.1 Central Approach

The approach of the modeling effort was to collect as much specific data as possible for each of the 2,000 POTWs subject to the General Pretreatment Regulations. The model relies heavily on the centralized data bases (NEEDs, Dun and Bradstreet, PCS) and projects average data characteristics where specific data were not available. The model has three conceptual modules:

1. Selection of a regulatory alternative and designation of major baseline assumptions.

2. Effects on industry; including environmental effects such as sludge quality and quantity, and effluent quality; and financial effects such as pretreatment related costs, sludge disposal costs, etc.

3. Effects on POTWs -- including environmental effects such as influent and effluent concentrations, receiving stream flow and water quality impact, sludge quality and air emissions of volatile toxic pollutants; and cost factors such as municipal pretreatment program costs.

The computer model performed the following key computations after receiving the input data:

1. Identification of all industrial users (IUs) served by a POTW.

2. Prediction of the average effluent flow and characteristics and pretreatment cost for each IU.

3. Addition of a baseline concentration of toxic pollutants to account for domestic and commercial contributions.

4. Adjustment of each IU flow to reflect the actual industrial flow at that POTW (normalization).

5. Application of an average POTW removal efficiency for each pollutant depending on its level of treatment.

6. Calculation of toxic pollutant concentrations in the POTW influent, effluent, and sludge and summation of appropriate costs.

7. Effects of the POTW effluent on stream quality and contribution of the POTW to potential water quality violations.

The model uses a variety of adjustments to account for discrepancies among data sources and to fill in missing data. These factors are discussed in detail in Appendix C-3. A simplified flow diagram of the model is presented in Figure 2-4.

2.2.3.2 Data Sources

Table 2-2 identifies the major data elements required to operate the model and the sources for each element. The principal data sources are identified below.

1. Dun and Bradstreet's (D&B) marketing service provided the information which identified a count of IU's in each POTW's jurisdiction by SIC Code. This data is on a computer tape.

2. The Permit Compliance System (PCS) data base provided the number of direct dischargers in each POTW. These are subtracted from the D&B listings to arrive at the number of indirect dischargers at each POTW. We then normalized that information to the total industrial flow.

3. EPA Effluent Guidelines Division (EGD) supplied the effluent flow and pollutant concentrations for each of the 34 categorical industries included in the model. EGD also supplied the removal efficiency for each pollutant required by PSES, the associated pretreatment technology costs, and the SIC code definition of each industry.

Other data derived from EPA estimates include:

- Sludge disposal costs
- Applicable stream quality criteria
- Adjustments to D&B to match the number of IU's nationwide counted by EPA
- POTW removal efficiencies (40 POTW Study)
- Nonindustrial contribution to POTWs (40 POTW Study and 4 City Study)

FIGURE 2-4. Simplified Flow Chart of the Computer Model

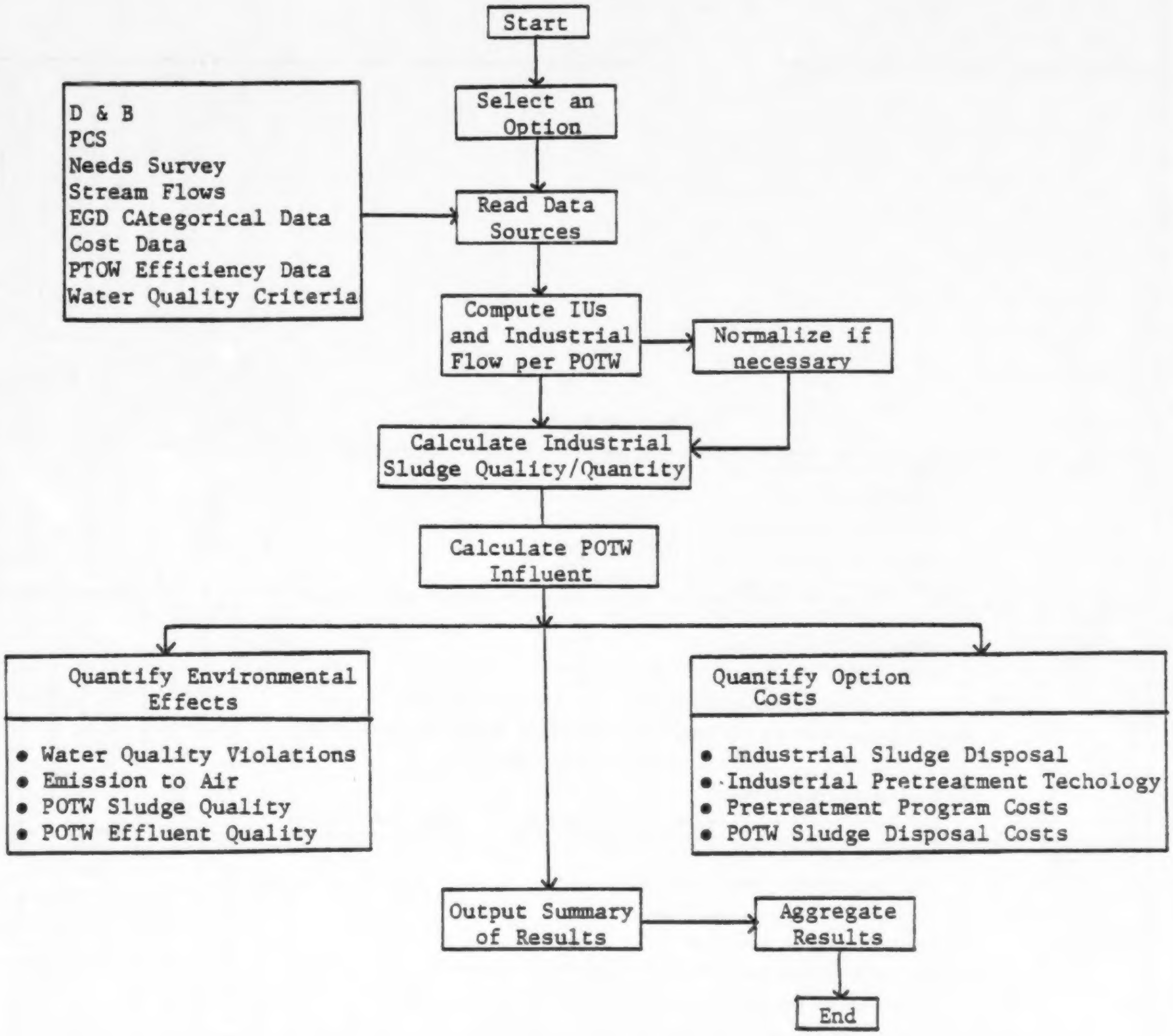

Start
Select an Option
D & B
PCS
Needs Survey
Stream Flows
EGD CAtegorical Data
Cost Data
PTOW Efficiency Data
Water Quality Criteria
Read Data Sources
Compute IUs and Industrial Flow per POTW
Normalize if necessary
Calculate Industrial Sludge Quality/Quantity
Calculate POTW Influent
Quantify Environmental Effects
• Water Quality Violations
• Emission to Air
• POTW Sludge Quality
• POTW Effluent Quality
Quantify Option Costs
• Industrial Sludge Disposal
• Industrial Pretreatment Techology
• Pretreatment Program Costs
• POTW Sludge Disposal Costs
Output Summary of Results
Aggregate Results
End

TABLE 2-2. MAJOR DATA SOURCES USED BY THE COMPUTER MODEL

DATA GROUP	DATA INPUT ELEMENT	Dun & Bradstreet	EPA Permit Compliance System	EPA Needs Survey	EPA Effluent Guideline Div. Data	40 POTW Study	4 City Study	Engineering Calculations	U.S. Geological Survey & STORET	EPA Regulations/Estimates	EPA Office of Water Program Operations	RCRA Publications	General Technical Literature
POTW Data	POTW ID & Location			●									
	POTW Flow			●									
	POTW Level of Treatment			●									
	Methods of Sludge Disposal Used by POTW			●									
	POTW Removal Efficiency of Priority Pollutants					●		●					●
Data On Industrial Users	Industrial Flow to POTW			●									
	Number of IU's per Category	●											
	Total Number of Direct IU's per Category		●										
	Total Number of Industrial Plants per Category in U.S.				●								
	Total Number of Direct Industrial Dischargers Per Category in US				●								
	Average Model Industrial Plant Flow per Category				●								
	Raw Waste Concentrations				●								
	Raw Waste Concent. Assuming No Pretreatment In Place (Baseline)				●								
Sludge Generation/ Water Quality Data	Industrial Sludge Generation Rates							●					●
	Municipal Sludge Generation Rates							●					●
	Average Receiving Stream Flows								●				
	Low Receiving Stream Flows								●				
	Receiving Stream Water Quality Criteria for Aquatic Life									●			
	Receiving Stream Water Quality Criteria for Public Health									●			
	Volatilization Rate of Volatile Toxic Organics					●		●					
Cost Data	Unit Cost for Pretreatment Technology				●								
	Cost Estimate for Development of Local Pretreatment Programs							●			●		
	Cost Estimate for Implementation of Local Pretreatment Programs							●			●		
	Unit Industrial Sludge Disposal Cost									●		●	
	Unit Municipal Sludge Disposal Cost Per Method									●		●	
Miscellaneous Data	Pollutant Concen. Contrib. by Non-Indus. Sources to Model POTW					●	●						
	Matching between SIC Codes and Category Codes				●								

4. The EPA NEEDs Survey provided the total flow, industrial flow and sludge disposal method(s) for each POTW. The NEEDS Survey was also used for generating descriptive statistics on the POTW population.

5. STORET and USGS data bases were used to determine the applicable stream flow for POTW discharges.

2.2.3.3 Weaknesses of the Modeling Effort

The model was designed to simulate the interactions of industry, the POTW and the environment at each municipality. However, the model was designed primarily to indicate specific differences between various pretreatment options. Accordingly, the results calculated for any particular POTW are often inaccurate because of the generalizations and normalization assumptions needed to design the model and because of certain data deficiencies. Nonetheless, the aggregate results closely represent the actual cost and environmental effects expected from pretreatment. The major omissions and assumptions of the modeling exercise that affect the conclusions are:

POTW Module Weakness

- Conventional pollutants are not addressed, except as they affect sludge generation. EPA data for each of the categorical industries does not always include treatability of conventionals and removal by pretreatment technologies to be incorporated into the model. This could be taken into account in future analyses.

- The POTW removal efficiency for each pollutant in the model is identical for all POTWs within a given level of treatment. The most representative data on priority pollutant removal by a POTW is the EPA 40 POTW study which only includes well operating plants. The median removals from this study are used in the model. As a result, the estimates of possible water quality violations are probably a minimum.

- Municipal sludge was defined to be non-hazardous. The cost of municipal sludge disposal is, therefore, not a function of level of contamination with toxic pollutants from industry -- no matter how severe the contamination. Consequently, improved sludge quality will not have any quantifiable economic effect in the model. If EPA issued new sludge criteria, then certain sludge disposal options utilized by POTWs might need to be replaced by more costly options. This result could increase the cost effectiveness of some pretreatment options.

- Ambient water quality data for toxic pollutants is not available for most water bodies. Therefore, the model could not calculate the incremental degradation caused by the POTW discharge. As a result the actual number of violations are likely to be substantially higher than those calculated by the model, especially when several POTWs and other direct dischargers are on one stretch of a stream. The model could be modified to take into account other discharges so that the marginal water quality impacts of each POTW can be calculated.

Industrial Module Weaknesses

- The only common denominator between the NEEDS Survey information of POTWs and D&B identification of IUs is the city name. Consequently, IUs within a POTW service area but in a suburb or different city will not be counted in this method. This affects the distribution of industry in each POTW simulation. The model uses EPA waste load data for each of the categorical industries to construct the influent to the POTW. Accordingly, errors in the identification of industrial users' impacts the environmental and costs outputs from the model for individual POTWs. However, these errors have only minimal effect on the aggregate results.

- Within cities with multiple POTWs, D&B cannot distinguish which POTW services each IU discharger. This error is minimized by the flow normalization procedure described in Appendix C-3.

- Each IU is assumed to have the characteristics of the EGD model plant. As a result, the characteristics of an individual POTW will contain errors related to the degree to which actual IUs in that system vary from the national composite. Again, this assumption leads to an understatement of water quality impacts.

- EGD has not entirely verified all organic priority pollutant discharge data from industry categories. Model plant data are especially suspect for the organics and plastics industry due to diversity within the industry. Consequently total toxic organics had to be treated as a group in the model rather than individually. Therefore, the model does not now estimate water quality criteria exceedences for toxic organic pollutants.

- EGD has not entirely verified the amount of metal pollutant discharge from industrial categories.

- Industrial sludge was defined to be hazardous. In light of the current delisting of certain industrial wastes of hazardous this assumption results in an overstatement of disposal costs.

Overall Data Weaknesses

- The bench mark for water quality impacts of POTW discharges on the model is the Federal Water Criteria, and Drinking Water Standards. State standards were evaluated but were not found to be better for use in the model.

- Stream flow data is only available for 703 streams from computerized data bases and other readily accessible information. However, both the 132 POTW Data Base and the 703 stream flows available for the 2,000 POTWs show similar trends. For both groups, the average stream flow is approximately 10,000 cfs, influenced by a small number of very large streams. The median stream flow from the 703 streams is approximately 500 cfs. versus 400 cfs. for the 132 POTWs. Since the characteristics of the 132 POTWs are nearly identical to those of the entire set of POTWs (this is documented in Section 2.2.1.2), it is likely that the 703 stream flows are also representative of the distribution of streams servicing the 2,000 POTWs. EPA is currently reviewing the representiveness of the stream flows and dilution ratios used in the model.

2.2.3.4 Aggregation of the Modeling Results For Comparison of Options

As explained previously, the model calculates a variety of cost and environmental quality data for each POTW. The last step in the modeling exercise is preparation of an aggregate summary table, presenting the national costs, and the net improvement in water, air and sludge quality. The aggregation output can be used to compare the results of various pretreatment options. Items that appear on the aggregation summary include:

- Industrial sludge quantity and quality
- POTW sludge quantity and quality
- POTW influent and effluent quality
- Applicable Water Quality and Health Criteria
- Ambient stream concentration (POTW effluent concentration/dilution ratio)
- Average Incremental Percent of Water Quality criteria consumed by the POTW discharged
- Number of POTWs exceeding water quality criteria.

The aggregate results closely match available EPA national projections and measurements. A detailed analysis of the model's accuracy is presented in Appendix C-4, and the model results are summarized in Chapter 4. In general, the model appears to be a credible simulation of a POTW system and a reasonable analytical tool for quantifying the national impacts of alternative pretreatment programs.

Aggregate results are more representative of national cost and environmental impact than is the result for a particular POTW. Inaccuracies in individual POTWs could be greatly minimized by improving the quality of the input data. For example, by contacting the POTW to determine its actual service area, the accuracy of local industrial pretreatment costs and industry discharge calculations could be improved greatly. Thus, the model is a useful predictive tool for local POTWs and States having accurate municipal data. Moreover, the use of local site specific water quality and local sludge criteria would enable the model to be used to optimize the levels of industrial waste control needed to meet local environmental goals at specific POTWs.

2.2.3.5 Sensitivity of the Model

The measure used by the model to assess water quality criteria is exceedances, which are defined to be an incremental stream concentration for any pollutant contributed by a POTW that exceeded the National Water Quality criteria. This measure, although useful is limited in that the number of exceedances is primarily driven by the ratio of stream flow to POTW flow—the dilution ratio. Combined with the very low criteria for some pollutants, this caused the exceedances to be fairly insensitive to industrial flow characteristics. The example below serves to illustrate the problems.

EXAMPLE 1

Cadmium has an aquatic life chronic toxicity of 25 ug/l. The model projects a cadmium contribution of 3 ug/l from non-industrial sources of which 50 percent (1.5 ug/l) will pass through a secondary POTW. Consequently, any POTW with a dilution ratio of 60 to 1 (1.5 ug/l ÷ 0.025 ug/l), or less will exceed the cadmium limit if no industries are present. Pretreatment in any cities in this dilution range will not prevent the discharge from causing exceedance.

EXAMPLE 2

Conversely, at POTWs with very large stream dilution ratios even a large industrial flow with no pretreatment may not cause a violation. Using cadmium, a POTW with 10 percent of its flow from metal finishing operations would expect influent cadmium levels to increase by 24

> ug/l, with 12 ug/l passing through the plant. Added to the 1.5 ug/l effluent concentration from non-industrial sources, an exceedance would be caused only if the dilution ratio for that POTW was less than 540 to 1 (13.5 ug/l ÷ 0.25 ug/l). The median dilution ratios at the 703 municipalities for which flow data were available is only 110.
>
> Consequently, for a signficant number of POTWs with small or large dilution ratios, the level of pretreatment has no effect on the number of exceedances.

To increase the sensitivity somewhat, the model also indicates POTWs that exceed 50 percent and 25 percent of the water quality criteria. These numbers implicity assume that the POTW is not the only discharger on a stream, and set the other sources of pollutant equal to the POTW concentration or three times the POTW concentration respectively.

The model is much more sensitive to pretreatment options where it predicts absolute values, such as POTW influent concentration, effluent concentration or sludge concentrations. These values are directly calculated from the input conditions and can be used to indicate the absolute and percentage differences between pretreatment options. These results and sensitivities are discussed in more detail in Appendix C-4.

2.3 Benefits Investigation

2.3.1 Introduction

In this report the benefits of pretreatment are described both qualitatively and quantitatively. Three quantitative measures of water related benefits are: 1) changes in effluent pollution loadings resulting from pretreatment; 2) improvements in water quality as indicated by the elimination of exceedances of federal water quality criteria; and 3) dollar values of water based recreation activities, such as boating, fishing, and swimming which could be expected to occur given improved water quality. This section briefly describes the methods used to monetize recreation benefits. The assumptions of the approaches used, and their limitations are also discussed. The results of the analysis are given in Chapter 4. A more detailed discussion of the estimation techniques is provided in Appendix E.

2.3.2 Approaches to Benefits Estimation

Methodology

A methodology that could be used within the time and resource constaints of this study was developed for monetizing the benefits of pretreatment. This methodology was used to estimate recreation benefits for 17 municipalities in which the model estimates that exceedances of federal water quality criteria are all eliminated as a result of pretreatment. Benefits associated with boating, fishing, and swimming are monetized for each of these cases by combining local information on affected stream area and its capacity for recreation use, with estimates of the values attached to the different forms of recreation by individuals. These values, or benefits "factors" were developed (in conjunction with EPA) from several national and case specific studies of the benefits of water pollution control.

Two different approaches to estimating benefits were used for each case where exceedances are eliminated. One approach estimates total user benefits resulting from boating and fishing which are assumed to occur only after all exceedances are eliminated. This is done by first estimating the number of individuals that could participate in these activities (based on the full use capacity of the area of water made cleaner and on the number of recreation days available in a year), and then multiplying the number of participants by the value per person per day of activity. The estimates of fishing and boating capacity are made using recreation planning standards adopted by the State of Ohio in its State Comprehensive Recreation Plan.

The other approach monetizes the user benefits associated with achieving water of swimmable (and therefore boatable and fishable) quality. These estimates are made by estimating the number of households living in the county or counties containing or adjoining the affected area of water, and multiplying that number by the value per household of having swimmable water nearby. This approach differs from the above approach in two ways. First, while the other method only measures fishing and boating benefits, this method measures fishing, boating, and swimming benefits. Second, while the first approach attempts to estimate use capacity based on the area of water available, this approach measures benefits based on the population available to recreate in or on the water, without considering whether the area of water available is sufficient to support the local population. Neither approach measures non-user benefits, which include existence, or option value, and aesthetics. Assumptions and limitations of these approaches are discussed next.

Assumptions and Limitations

The approaches used here monetize only user recreation benefits. But health effects, and reduced water treatment costs may be significant for toxics, and non-user benefits from cleaner water can be a substantial fraction of total benefits. This limitation contributes to an underestimation of total benefits.

The underlying assumption basic to both approaches is that recreation uses are achieved only in cases where all exceedances are eliminated by pretreatment. Implicit in this assumption is a base case scenario in which no recreation uses of water occurs if one or more of the federal water quality criteria (regardless of which criteria) is exceeded on the segment of water affected by the POTW. Achieving recreation uses is thus assumed to be a threshold effect. In general, this assumption probably leads to overstated benefits, as some boating, fishing, or swimming may occur in areas having exceedances.

Another assumption common to both estimation methods is that the POTW is the only source of pollution discharges. And as a result, all benefits of cleaner water are attributed to cleaner POTW effluents. While this assumption contributes to an overestimation of benefits in those cases where exceedances are eliminated, it does not capture the contribution of POTWs to attaining uses where pretreatment alone does not eliminate all exceedances.

Finally, the accuracy of the estimates of total benefits is limited to the accuracy of the estimates of affected stream area, population, number of recreation days available, and the national benefits factors, which may or may not reflect local recreation values. Other assumptions and limitations are discussed in Appendix E.

Tests of Reliability

Both of the approaches described above have been tested by applying them to three EPA case studies which used significantly more complex estimation techniques to monetize recreation benefits. Comparison of the results indicates that the use of simple benefits factors, planning standards, and population estimates produces monetized benefits in the same range as those calculated using the more sophisticated methods (see Appendix E Table E-6). Of course, it is uncertain whether the performance of the simpler approaches in these cases is representative of their performance in general.

Use of Results

The results for the 17 POTWs can provide a useful indication of whether the aggregate benefits and costs are roughly commensurate for the POTWs analyzed, but probably should not be relied on for making program tradeoffs. Conclusions for the individual cases studied are likely to be valid in those instances where benefits greatly exceeded costs or where costs greatly exceeded benefits.

3. ASSESSMENT OF THE NEED FOR CONTROL OF INDUSTRIAL DISCHARGES TO POTWs

This chapter summarizes findings on problems experienced by POTWs receiving industrial wastes. Data supporting this analysis were drawn from the studies discussed in Chapter 2 and presented in Appendix B. Modeling results from Appendix C for two pretreatment alternatives are also utilized for comparative purposes to assess the effectiveness of pretreatment in controlling industrial wastes. These alternatives are:

(1) Current level of pretreatment in place;
(2) Estimated level with the current 40 CFR 403 program including all categorical standards.

Appendices B and C should be consulted for information or additional details on research methodologies, data sources, assumptions, and weaknesses in the analysis.

The purpose of this discussion is to quantify the need to control indirect discharges of toxic pollutants. To a large extent the interpretation of this analysis depends on statutory or regulatory triggers which define the acceptability of levels of toxic discharges to the environment. Unfortunately, specific toxic limits for ambient water quality are not universally accepted and the development of sludge criteria is in its infancy. As a result, it is not possible to report on the severity of an environmental impact with confidence. However, the relative impacts can be compared among options. In addition, the amount of pollutants which pass through POTWs to the environment has been calculated and are reported in this chapter.

In this analysis indicators of the magnitude of environmental problems are examined and estimates of improvement that would be afforded by pretreatment are made. The central emphasis of this analysis is on the need to control toxic pollutants discharged to POTWs by industry. In addition, the need for a general §403-type program to establish the impact of industry on POTW operations and to control prohibited discharges is addressed in this chapter. The environmental problems examined in this section are principally those which the pretreatment program was designed to prevent, namely: water quality degradation from toxic pass-through, interference and by-passes, operational problems caused by toxic interference, and contamination of sludges by toxic pollutants. In addition, qualitative results are presented on worker health and safety, air pollution, and groundwater contamination problems which occur at POTWs that receive industrial wastes.

3.1 WATER POLLUTION

The measures of water pollution detailed in the previous chapter are NPDES violations and instances where water quality standards are exceeded. In this section, documentation of exceedances and NPDES violations are evaluated to determine the extent and severity of water pollution problems caused by industrial dischargers. For several reasons the data compiled on exceedances of water quality criteria should be viewed as minimum values. First, they do not include the impact of by-passing of raw waste by the POTW on water quality. This impact is potentially severe. Second, the data on ambient water quality is weak and no allowance is made in this analysis for background levels of toxics. One would expect additional exceedances of water quality criteria without pretreatment if background levels of toxics could be specified accurately. Thus, the normalization assumptions discussed in Section 2.3 lead to under-estimates of the number of water quality violations.

3.1.1 NPDES Permit Violators

Priority pollutants from industrial and nonindustrial sources are often discharged through POTWs to the environment. The release of toxic pollutants in POTW effluents is termed "pass through" and may cause the facility to violate its NPDES permit, or cause water quality standards (which protect the use intended for the receiving body) to be exceeded. A simple way to measure the need for pretreatment is to count violations of NPDES permit limits and water quality standards for POTWs with and without pretreatment in place. Unfortunately, very few POTWs have toxic limits in their NPDES permits. The 132 Study (representative of the 2,000 POTWs requiring pretreatment programs) revealed that 87 percent of POTWs do not have metals limits and 85 percent do not have toxic limits in their NPDES permits. Accordingly, NPDES violations are not a good indicator of toxic pass-through problems at POTWs. Because the number of POTWs in the 132 Study that have NPDES permit limits specified for metal and toxic pollutants is so small, an analysis of violations for these pollutants is not significant. However, because 94 percent of the POTWs in the 132 Study have NPDES permit limits specified for conventional pollutants, the analysis of violations for these pollutants is signficant. Of the POTWs with limits for conventional pollutants specified in their permits, 40 percent report violations for these pollutants. The average frequency of violations for these POTWs is reported as occurring 39 percent of the time.

The 77 POTW Study, which focused on POTWs treating less than 5 mgd, indicates that 66 percent experience permit violations, and almost two thirds of these violations are attributed to industrial contributions. Many of the plants violated monthly as well as daily discharge limits. This finding is corroborated by data in the O&M File that show 60 percent of POTWs reporting O&M problems associated with industrial waste were in violation of NPDES permits. Violation of conventional limits may be indicative of upset and interference problems which are likely to cause reduced incidental removal and high amounts of pass-through of toxics at these POTWs.

3.1.2 Exceedances of Water Quality Criteria

There is little data on the water quality impacts of POTWs in the literature. In this project the POTW model was used to simulate the interaction among industrial users, POTWs, and receiving bodies. The analysis was conducted on the 665 POTWs for which the stream flow data is complete. Results were scaled up to cover 1,839 POTWs out of the population of 2,000 POTWs estimated by EPA and the States to need pretreatment programs. (The remaining 161 POTWs were found to have no flow according to the Needs Survey--attributable either to file error or that the plant is currently under construction--and were therefore excluded from this analysis. For the same reason the 703 POTWs for which we had stream flow data were scaled down to 665.) Nine toxic metals, cyanide, and total organics were modelled in the project. The model uses the POTW-to-stream dilution ratio to calculate the concentration of each pollutant in the receiving water body discharged from the POTW. This concentration is compared to Federal water quality criteria as a measure of water quality impacts. Table 3-1 summarizes the percentage of plants which would violate the Federal water quality criteria for each pollutant, assuming the current level of pretreatment in place.

3.1.2.1 Results of Modeling Analysis

Results of this analysis are presented in Table 3-1 for two pretreatment options:

(1) Current level of pretreatment in place, and
(2) The current 40 CFR 403 pretreatment program with categorical standards.

The data shows that nearly half of the POTWs (46 percent or 845 out of 1,839 plants) exceeded 100 percent of the the cadmium criteria. Data set D on Table 3-1 compiles these data. However, few POTWs exceed the criteria for many of the other pollutants. In every case that another criteria is exceeded, the cadmium value is also exceeded. The exceedances in Data set D were calculated assuming that background levels of pollution are zero and that the POTW is discharging into pristine waters. In short, the POTW is the sole source of water pollution.

Perhaps a more realistic way to measure the impact of indirect users is to tabulate the number of POTWs exceeding 50 percent of the water quality criteria. This approach assumes that other sources are accounting for a level of pollution equal to half of each criteria. If the marginal contribution of the POTW is at or above the remaining portion of the criteria, then an exceedance will occur. Data set C compiles the results of modeling this assumption.

TABLE 3-1. MODEL INDICATORS OF WATER QUALITY VIOLATIONS

(A) AVERAGE PERCENT OF AQUATIC WATER QUALITY CRITERIA USAGE BY POTWs
(Based on Chronic Aquatic Life Criteria Values and Mean Annual Stream Flow)

	With Current Amount of Pretreatment in Place	With Full Pretreatment	Change
Silver (Ag)	127	120	7
Cadmium (Cd)	972	732	240
Chromium (Cr)	7	2	5
Copper (Cu)	26	12	14
Mercury (Hg)	6	5	1
Nickel (Ni)	5	1	4
Lead (Pb)	25	19	6
Zinc (Zn)	7	3	4
Cyanide (Cn)	58	20	38

(B) PERCENT OF POTWS EXCEEDING 25% OF AQUATIC LIFE WATER QUALITY CRITERIA

Silver (Ag)	39	38	1
Cadmium (Cd)	66	62	4
Chromium (Cr)	6	0.8	5
Copper (Cu)	18	11	7
Mercury (Hg)	5	4	1
Nickel (Ni)	4	0.3	4
Lead (Pb)	18	16	2
Zinc (Zn)	7	3	4
Cyanide (Cn)	25	16	9

(C) PERCENT OF POTWS EXCEEDING 50% OF AQUATIC LIFE WATER QUALITY CRITERIA

Silver (Ag)	29	28	1
Cadmium (Cd)	57	53	4
Chromium (Cr)	3	0.2	3
Copper (Cu)	12	6	6
Mercury (Hg)	2	2	0
Nickel (Ni)	2	0.2	2
Lead (Pb)	11	10	1
Zinc (Zn)	2	1	1
Cyanide (Cn)	18	10	8

(D) PERCENT OF POTWS EXCEEDING 100% of AQUATIC LIFE WATER QUALITY CRITERIA

Silver (Ag)	19	18	1
Cadmium (Cd)	46	43	3
Chromium (Cr)	2	0	2
Copper (Cu)	7	3	4
Mercury (Hg)	1	0.3	1
Nickel (Ni)	1	0	1
Lead (Pb)	6	5	1
Zinc (Zn)	1	0.2	1
Cyanide (Cn)	11	6	5

Almost 60 percent of the POTWs would violate the cadmium criteria. Additionally, a few other criteria are becoming important (silver at 29 percent and cyanide at 18 percent).

If the background level is assumed to be 75 percent of the water quality criteria, then POTWs contributing 25 percent or more will cause exceedances. Data set B shows that two-thirds of the POTWs will exceed the cadmium criteria, and 40 percent will exceed the silver criteria. In addition to cyanide (at 25 percent) and copper (at 18 percent), lead is also being exceeded routinely (at 18 percent) under this assumption.

Data set A shows the average percentage of the water quality criteria for each pollutant attributed to the POTWs modeled. Not surprisingly, the largest values, for cadmium and silver, in data set A are greater than 100 percent. The values reflect the low criteria for these parameters. The data shows that chromium, mercury, nickel, and zinc criteria are not likely to be exceeded because, at an average POTW, other sources would have to contribute more than 90 percent of the water quality criteria to cause exceedances for these parameters.

The model was also used to measure the impact that categorical standards would have on reducing water quality exceedances from their current level. Table 3-1 includes these data. The improvement is not dramatic. Categorical standards only reduce by a few percent the number of POTWs with exceedances. Assuming pristine conditions, exceedances at only 61 POTWs were eliminated entirely. The reason for so few reductions in exceedances is that the water quality criteria for the pollutants are relatively low. When industry pretreats at these POTWs, the residual pollutant levels in the POTW effluent contributed by non-domestic sources are still high enough to cause the criteria to be exceeded. Generally, the dilution ratio (stream flow to POTW flow) at the POTWs causing exceedances is low. However, as discussed in the next subsection, the fact that an exceedance is not eliminated does not mean that pretreatment has not had a beneficial effect on water quality.

3.1.2.2 Explanation of Results

The five critical variables which determine whether POTW discharges would cause water quality criteria exceedances are:

1) Toxics contribution from industrial and non-industrial sources to POTW influent
2) POTW removal efficiency
3) Stream flow and dilution ratio
4) Background (ambient) water quality applicable
5) Water quality criteria

Each of these variables can significantly affect the number of exceedances. However, because of the actual range of their values, some variables are more critical than others. For example, POTW removal efficiency is not very critical because (in the model) constant efficiencies were assumed for each type of treatment (primary, secondary and tertiary). The removal across treatment types for copper is representative. It varies by a factor of about 4; from 82 percent for tertiary treatment to 19 percent for primary treatment. This variation is hardly signficant when compared to the variation in dilution ratio.

Dilution ratio is an index of POTW flow to stream flow below the POTW. These ratios can vary greatly. For the 665 POTWs the range is from 1 to 1 up to 30,000 to 1. Clearly, the dilution ratio can cause water quality to vary by several orders of magnitude. Accordingly, it is a major determinant of exceedances.

The value of the water quality criteria also has a signficant impact on exceedances. Table 3-2 lists the aquatic life criteria for the pollutants analyzed in this study. Notice that the value for nickel is about 4 thousand times larger than for cadmium. Obviously, exceedances for cadmium are more likely than for any of the other pollutants. The data on Table 3-1 discussed

TABLE 3-2. THRESHOLD DILUTION RATIOS

Pollutant	Aquatic Life Water Quality Criteria (ug/l)	Mean POTW Effluent (ug/l)#	The Critical## Ratio Based on Medium Effluent Concentrations
Ag	0.12	1.0	8/1
As*	440.0	1.0	None
Cd	0.025**	3.0	120/1
Cr	44.0	33.0	1/1
Cu	5.6	38.0	7/1
Hg	0.2	0.13	1/1
Ni	96.0**	56.0	1/1
Pb	3.8**	12.0	3/1
Zn	47.0	145.0	3/1
Cn	3.5	151.0	43/1

SOURCE: 40 POTW Study

Critical dilution ratio: The ratio at or below which a water quality exceedance would be expected to occur at half of the POTWs.

* The acute number is presented since there is no chronic water quality criteria value for arsenic.

** Based on hardness of 100 mg/l $CaCO_3$.

in the previous section bears this out. The most exceedances occurred for cadmium.

Water quality criteria can be used to calcuate a "critical" dilution ratio for each contaminant. This is done by dividing the criteria into the mean POTW effluent concentration of the contaminant. Table 3-2 lists critical dilution ratios using mean effluent concentrations from the 40 POTW Study. As expected, the highest value is for cadmium. This means that even at a dilution as large as 120 to 1 that cadmium exceedances are expected. Since the critical dilution ratios are calculated using mean effluent values, half the plants facing the critical dilution ratio should exceed the criteria. Again, the data from the model presented in the previous subsection supports this analysis. The average dilution ratio for the 665 POTWs is 110 to 1. This is close to the critical dilution ratio for cadmium (120 to 1), and nearly half of the POTWs (46 percent) violate the cadmium criteria.

Critical dilution ratios can probably be used as a preliminary method to spot likely water quality problems caused by POTWs. The only data it requires is stream flow and the applicable water quality criteria.

Although nearly half of the POTWs modeled cause water quality to be exceeded, very few (only 61) had their exceedances eliminated through categorical standards. The reason for this is that the contribution of pollutants from nonindustrial sources plus the residual discharge from industry are often sufficient to trigger exceedances.

Table 3-3 lists the mean contribution of pollutants from industrial and non-industrial sources in POTW influents. Clearly, most of the contribution is from industry. However, domestic sources alone will cause an exceedance if the water quality criteria is low. For example, the removal efficiency for cadmium by POTWs at secondary treatments is 50% so that non-industrial sources contribute an average of 1.5 mg/l of cadmium to receiving bodies (.50 x 3.0 mg/l). The

TABLE 3-3. RELATIVE CONTRIBUTION OF INDUSTRIAL AND NON-INDUSTRIAL SOURCES TO POTW INFLUENTS

	Influent Concentration		
Pollutant	Mean Non-Industrial Sources (ug/1)	Average* Influent Concentration (ug/1)	Percent from Industrial Sources
Ag	5.0	9.0	44%
Cd	3.0	38.0	92
Cr	50.0	174.0	71
Cu	61.0	224.0	73
Hg	0.3	0.55	45
Ni	21.0	118.0	82
Pb	49.0	98.0	50
Zn	175.0	717.0	76
Cn	41.0	544.0	92

*SOURCE: 4 City POTW Study, and 40 City POTW Study threshhold dilution ratio for non-industrial sources to trigger an exceedance for cadmium is 60 to 1. Over 25 percent of the POTWs modeled would exceed the cadmium criteria just from non-domestic sources.

The above analysis does not mean that industrial pollution control is not important. It does mean that at many municipalities in the nation, other pollution control programs, in addition to controls on industrial users, are needed to meet water quality goals.

3.1.2.3 Characteristics of POTWs Causing Exceedances

From the previous discussion one would expect to find exceedances at POTWs with low dilution ratios and large industrial flows. Table 3-4 supports this premise.

TABLE 3-4. DISTRIBUTION OF POTWS BY DILUTION RATIOS

PERCENT OF POTWS IN EACH DILUTION RANGE

	Dilution Ratios					
	0-50	50-100	100-200	200-500	500-1000	>1000
All POTWs	36.8	10.5	10.2	13.6	8.3	20.3
POTWs Currently with Exceedance	52.0	22.2	19.3	5.2	1.3	0

The table lists the percentage of firms in a range of dilution ratios for all POTWs as well as for the POTWs currently estimated to have exceedances. Not surprisingly, POTWs with exceedances are concentrated in the low dilution ratio range. Very few of these POTWs have dilution ratios greater than 200 to 1 (the average for POTWs with exceedences is 110 to 1). Conversely, the distribution of all POTWs is more uniform across the dilution ratio ranges. It is highest at the lower end of the range and nearly constant in the middle ranges. At the upper range, the concentration is again high, indicative of the overriding effect that dilution has on exceedances. None of the plants in this range showed any exceedances.

3.1.2.4 Limitations of the Results

A number of inherent weaknesses in the analysis need consideration when examining the significance of these findings. First, limitations in industrial raw waste-load data prevented the measure of toxic organics violations although they are probably occurring. Second, the modelling exercise forces averages to be employed for such variables as industrial influent and stream flow. Also data on the ambient water quality of receiving streams was incomplete so that variation in background levels of pollutants could not be accurately assessed. In actuality, industrial slug loads and low flow stream conditions make additional water quality exceedances possible. Nonetheless, these model results are useful for comparative purposes.

3.1.3 Effluent Improvement Comparisons

Several data sources demonstrate that industrial users constitute a major source of toxic pollutant contributions to POTWs. Table 3-5 shows the percentage of improvement in POTW effluent quality experienced (or projected) for cities with and without pretreatment. These data were taken from case studies of six municipalities and from a comparison of effluents from cities without pretreatment programs to similar cities with pretreatment programs from the 40 POTW Study. As would be expected, pretreatment significantly reduces the concentrations of toxic pollutants in POTW effluent for all but two parameters. An anomaly in the data occurs for cyanide and copper, which increased in concentration.

3.1.4 Bypass (and Overflow)

Bypass occurs when flow to a POTW is diverted either before it reaches the treatment works or within the treatment works, and is subsequently discharged to receiving waters with only partial treatment or with no treatment. These events may be intentional or unintentional, usually resulting from a combination

TABLE 3-5

PERCENT IMPROVEMENT IN POTW EFFLUENT QUALITY WITH PRETREATMENT PROGRAM

Pollutant Parameter	40 POTW Study(1)	Model	Selected Case Studies	Mean
Silver (Ag)	0	6	NA	1.5
Arsenic (As)	NA	26	66	36
Cadmium (Cd)	33	26	53	39
Chromium (Cr)	33	81	62	58
Copper (Cu)	(7)	57	(56)	-2
Mercury (Hg)	NA	29	65	49
Nickel (Ni)	(9)	74	28	32
Lead (Pb)	59	21	74	49
Zinc (Zn)	51	47	64	52
Cyanide (Cn)	16	NA	(30)	-7
Total Metals	26	63	36	40
Toxic Organics	75	70	99	82

(1) percent improvements are derived from different cities with and without pretreatment programs.

Data Sources: Appendices B-4, B-5, and C-3 of sewer overflows, precipitation, equipment failure, or in some instances, industrial overloads. Even though the bypass may not have been caused by industry, the industrial toxics which are present in the POTWs influent at the time of bypass are discharged directly into the environment without treatment. Thus, the occurence of bypass may cause toxics pass-through.

Bypassing does not significantly increase the yearly amount of pollutants entering receiving bodies. A calculation using the data reported above verifies this conclusion. The maximum bypassing (10 hours per month of all raw wastewater by 35 percent of the POTWs) would increase pollutions loads by only 3 percent per year. Since this loading occurs over short durations, they are acute rather than chronic occurences. Acute water quality criteria are much higher values than chronic criteria. As a result, only the most extreme by-passing events will cause acute water quality standards to be exceeded. Moreover, bypassing is often necessitated by heavy rain fall which overloads the sewers. Accordingly, industrial wastes which are bypassed are diluted by runoff which minimizes their impact on stream water quality.

Information from the O&M Data Base shows the occurrence of bypass at POTWs. Figure 3-1 shows that monthly bypasses occur across the full spectrum of POTW flow categories and levels of treatment. Overall, 35 percent of POTWs in the O&M File receiving industrial wastes experienced monthly bypass (33 percent of all POTWs in the data base had monthly bypass). A majority of these bypasses last for less than 10 hours, with durations reported ranging from 1 to over 24 hours per bypass.

3.2 INTERFERENCE AND UPSETS

Another major problem is interference with the operation of treatment plants resulting from industrial waste contributions. Interference occurs when high volumes or concentrations of pollutants inhibit or interfere with the normal operation of POTW processes, thereby hindering adequate treatment of domestic and industrial wastes coming into the plant. Upsets are an extreme

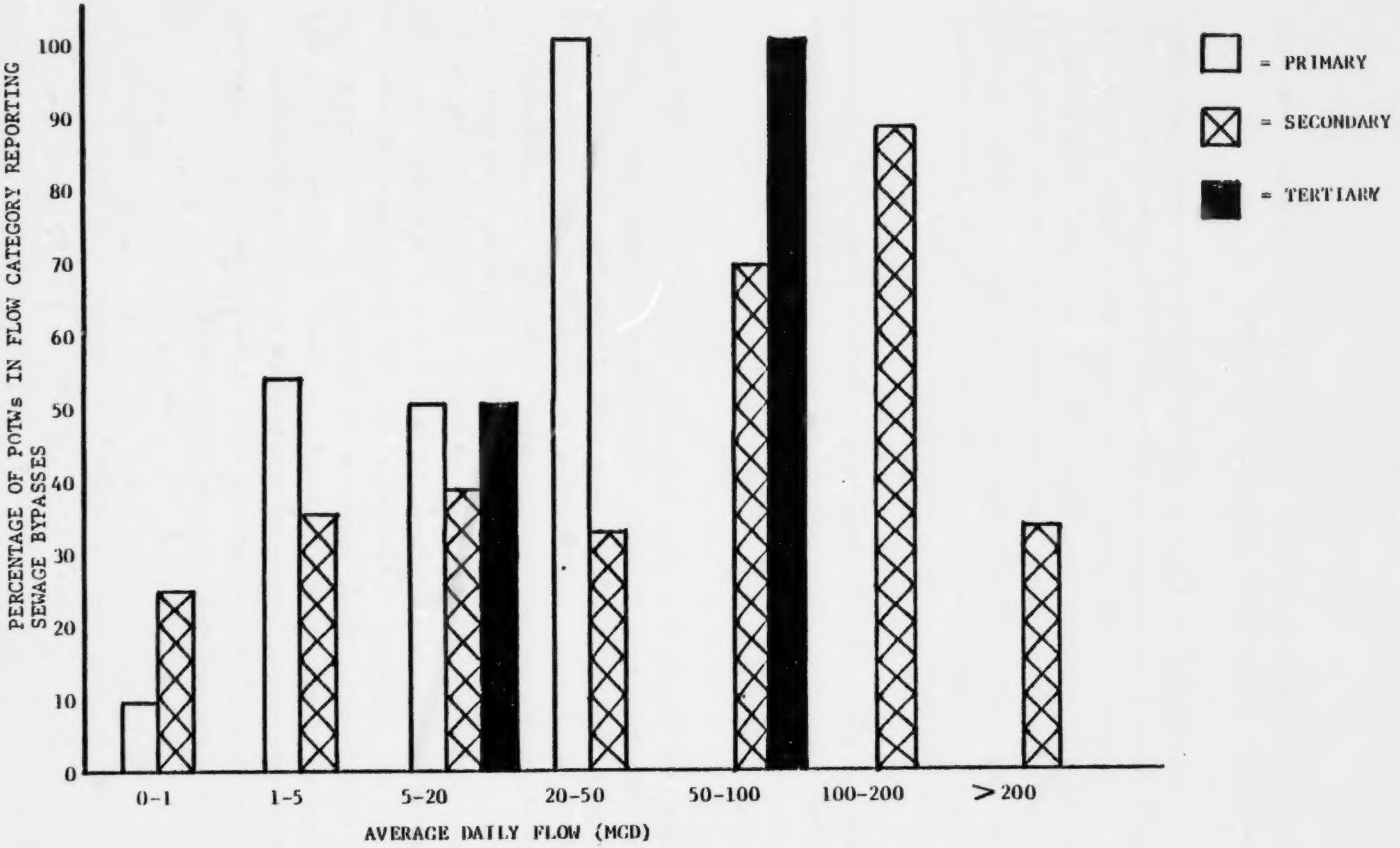


FIGURE 3-1. PERCENTAGE OF POTWs REPORTING MONTHLY SEWAGE BYPASSES BY AVERAGE DAILY FLOW CATEGORIES

type of interference where slug loads of pollutants destroy plant functions, and cause wastewater influent to passthrough untreated.

There is documentation on the prevalence of interference upsets, and operations and maintenance (O&M) problems at POTWs caused by industrial wastes. The 77 POTW Study reported a high incidence of interference upsets attributable to the food and electroplating industries. The O&M data base reveals that 72 percent of the 330 POTWs receiving industrial waste report an O&M problem associated with that waste. Thirty-eight percent of the 330 POTWs reported treatment process equipment failure as the O&M problem, and 42 percent reported sludge handling equipment failure as the problem.

O&M problems associated with industrial waste have no apparent correlation to POTW average daily flow. While most of the 330 POTWs reporting O&M problems receive less than 5 MGD, most of the POTWs in the O&M data base also receive less than 5 MGD average flow.

The data from the O&M file are bolstered by results of the 77 POTW Study which report that one-quarter of POTWs experienced one or more types of process upsets. Of those sustaining upsets, 84 percent claimed that industrial wastes contributed to the upsets. Additionally, 45 percent of the municipalities examined in the literature case studies reported that the key motivation for implementing a pretreatment program was the need to protect POTW operations and equipment from industrial slug loads. (The 132 study reported POTW protection as the motivation at 27 percent of the plants.) Prohibited discharge standards are the principal mechanism within the Pretreatment Program for control of interference. These standards are locally set and vary greatly from municipality to municipality, depending on local conditions. No attempt was made to forecast the effectiveness of pretreatment in eliminating interference in the modeling effort, because EPA does not have extensive verified data on conventional pollutants from the categorical industries.

3.3 SLUDGE CONTAMINATION

Few regulations for control of the disposal of contaminated sludges have been promulgated, so it is difficult to assess the constraints that cities will be faced with in disposing of their sewage sludges. Under current guidelines all municipal sludges may be treated as non-hazardous wastes.

Sludge contamination results from the incidental removal of toxic pollutants from the POTW wastewater influent in the course of treatment. Municipalities already face limited choices and high costs in disposing of POTW residuals. The contamination of these sludges with high concentrations of heavy metals and other toxic chemicals can further constrain sludge management options. Increased toxicity levels in municipal sludge may preclude cheaper disposal options such as use as a fertilizer or a soil conditioner. In addition, improper handling of contaminated sludges may lead to the leaching of toxic pollutants into groundwater, the introduction of metals into the food chain, and hazardous air emissions from sludge incineration.

The 40 POTW study showed that virtually all of the metal priority pollutants removed by the POTW collect in the resulting sludge stream. The concentration factors in both primary, secondary and combined sludges vary greatly, depending on the solids content and other factors, but metals usually ranged between 10 and 1,000. Volatile priority pollutants that were frequently present and sufficiently above their detection limits had concentration factors of between less than one and 10. The non-volatile organic priority pollutants had concentration factors between the two other groups.

Several priority pollutants which were reported below their detection limits in most POTW influents regularly were quantified in sludge streams. Pollutants exhibiting this tendency include antimony, arsenic, silver, selenium, phenanthracene/anthracene and pyrene. For example, arsenic was measured above its detection limit in 15 percent of all influent samples, but in 94 percent of all sludge streams. Table 3-6 presents concentration values for metals which the 40 POTW study found to accumulate in municipal sludges. It suggests that the ranges of toxicity in municipal sludges are considerable. Table 3-7 shows that the 2,000 POTW model produced similar concentrations for toxics in municipal sludge. Table 3-7 also demonstrates the effectiveness of pretreatment in reducing toxicity levels for most heavy metals and toxic organics in sewage sludge. For instance, pretreatment reduces total metals in sludge by 52 percent and total organics by 67 percent.

Dramatic improvements in sludge quality have been recorded by cities which have implemented pretreatment programs. For example, in Muncie, Indiana, a city with a large contribution of metal platers, sludge concentration (mg/kg-dry basis) of chromium went from 2,000 before pretreatment to 9.5 after pretreatment. Copper went from 1,750 to 700; nickel from 8,500 to 150, and zinc from 5,800 to 2,700. Table 3-8 compares the percent of improvement for sludge realized by selected case study cities against those predicted by our model. The results are remarkably consistent.

Results of the 77 POTW study further indicate the extent of contamination of categorical POTW sludge. Table 3-9 indicates that 25 percent of these small POTWs were either known or suspected to have contaminated sludges. Of those identified as having contaminated sludge, 87 percent of the municipalities attribute this contamination to industry and 67 percent reported that this contamination affected their disposal options. Contamination is not clearly defined by the POTWs, but this analysis assumes it to be the presence of heavy metals in those sludges that have been analyzed for pollutants. Contamination findings might even be higher given the high percentage of municipalities which have not analyzed sludges for the presence of priority pollutants.

Several factors affect the selection of disposal methods at the municipality level.

TABLE 3-6

CONCENTRATION OF SELECTED METALS IN SECONDARY SLUDGE FROM 40 POTW STUDY (mg/kg)

	Range	Average	Median
Cadmium	1 - 1622	157	14
Chromium	125 - 1762	730	422
Copper	150 - 3160	894	553
Nickel	13 - 803	240	121
Zinc	420 - 8468	2874	2167
Lead	40 - 1169		

Metal mg/kg

SOURCE: Federal Register

TABLE 3-7

SLUDGE QUALITY WITH AND WITHOUT PRETREATMENT FROM MODELING EXERCISE

AVERAGE POTW SLUDGE QUALITY (mg/kg dry wt)

	Without Pretreatment	With Pretreatment	Percent Improvement
Silver (Ag)	32	32	0%
Cadmium (Cd)	26	21	19%
Chromium (Cr)	831	222	73%
Copper (Cu)	563	274	51%
Mercury (Hg)	1.3	1.0	23%
Nickel (Ni)	181	60	67%
Lead (Pb)	147	132	10%
Zinc (Zn)	923	547	41%
Total Metals	2704	1296	52%
Cyanide (CN)	--	--	--
Toxic Organics	913	306	67%

TABLE 3-8

PERCENT IMPROVEMENT IN SLUDGE WITH PRETREATMENT PROGRAM

Pollutant Parameter	Case Studies	Model	Mean
Arsenic (As)	NA	0	0
Cadmium (Cd)	20	28	24
Chromium (Cr)	74	75	75
Copper (Cu)	51	50	51
Mercury (Hg)	-	13	7
Nickel (Ni)	75	68	72
Lead (Pb)	71	5	38
Zinc (Zn)	51	35	43
Total Metals	49	51	50
Total Organics	NA	70	70

Data Sources: Appendices B-5 and C-3.

TABLE 3-9

REPORTED INCIDENTS OF SLUDGE CONTAMINATION AT THE 77 POTWS

	Sludge Needs Analysis	Contamination Suspected	Contamination Known	Known Contam. Reportedly Caused by Industry	Contam. Affects Disposal Method	Practice Land Spread of Sludge
# of POTWS	22	5	15	13	10	27
% of Total (77)	29%	6%	19%	17%	13%	35%
% of POTWs Experiencing Problem Listed	-	23% of POTWS that need analysis	-	87% of POTWs with known contamination	67% of POTWs with known contamination	-

Source: Appendix B-3

Landfilling: Currently, 85 percent of municipalities dispose of their sludges by landfilling. Landfilling is regulated by §4004 of the RCRA Regulation. The following issues affect the future use of landfilling as a sludge disposal alternative:

- Typically, landfilling costs are $80/ton dry solids.
- Increased land costs and public opposition to siting of landfills could decrease their use.
- Increase landfill costs by forcing contaminated sludge to be disposed in §3000 secured RCRA landfills. This could have as much as a ten-fold effect on the cost of sludge disposal.

Landspreading: As a disposal alternative for municipal sludge, landspreading has seen decreased use in recent years. The following factors influence the use of landspreading for municipal sluge disposal:

- Landspreading today typically costs $60/ton dry solids.
- Cadmium criteria prohibits many municipalities from using landspreading as an alternative.
- Public opinion is typically adverse to landspreading.
- Decreased land availability and increased land costs could hamper future use of this alternative.

Incineration: Incineration/pyrolysis handles one million tons of sludge per year from the 2,000 municipalities which are subject to the General Pretreatment Regulations. The following factors could potentially influence the use of incineration as a municipal sludge disposal alternative.

- The typical cost of incineration today is $150/ton dry solids.
- High fuel costs, particularly where sludges are laden with heavy metals, have already forced many municipalities to go back to landfilling as a disposal method.
- Localities, such a Phildelphia, have no alternative to incineration since land availability is poor and shipping costs are high. In time, these restraints could force other municipalities to incinerate despite fuel costs.

- New technology is being developed (starved-air) which would appreciably lower incineration costs in the future.

Sludge handling costs vary significantly among the various disposal options. They range from $60/ton for landspreading to $150/ton for incineration. Excluding a low cost disposal option because of sludge contamination, can have a very significant impact on municipal sludge management costs.

3.4 ENVIRONMENTAL AND HEALTH CONSIDERATIONS

Three additional areas of concern in a discussion of environmental and health considerations as they relate to industrial discharge to POTWs are worker health and safety, air pollution and groundwater contamination. Unfortunately, they have received little attention in the technical literature. However, a few case studies have demonstrated the importance of these three subject areas in assessing industrial discharges to wastewater treatment facilities.

3.4.1 Worker Health and Safety

Exposure of POTW workers to airborne chemical hazards is the principal occupational health concern related to municipal wastewater treatment. The major source of these constituents are volatile organic compounds discharged to the public sewer from industrial sources.

In a recent study of 40 POTW facilities, volatile organic compounds were measured in the wastewater influent. Table 3-10 shows the average concentrations and detection frequencies of 11 compounds that are commonly found in POTW influent. An attempt was made to compare the presence of these compounds to airborne compounds which typcially cause health and safety problems. Table 3-11 briefly describes the airborne concentrations of these compounds in POTWs. It also shows the applicable exposure criteria, toxicological characteristics, physical properties and industrial sources of these chemicals.

TABLE 3-10
Average Concentrations of 11 Compounds

Volatile Organic Compound	(Concentrations (in ppm)			Health Effects			Physical Properties		Industrial Use
	Actually Measured[4]	TLV	PEL	Local-acute	Systemic acute	Chronic	VP[2]	BP	
benzene	---	10	1	skin irritant	CNS depressant	carcinogen of blood forming tissue	75mm	176F	Solvent, constituent of motor fuels
chloroform	---[5]	10	50		liver damage CNS effects	has caused cancer in humans when administered at high doses	160mm	142F	Solvent in pharmaceutical manufacture
1,2-dichloroethane	---	10	5	eye and respiratory irritant	narcotic effects	---	62mm	183F	Solvent, anti-knock compound
ethyl benzene	---[5]	100	100	eyes, nose, throat and skin irritant	---	---	7.1mm	277F	Solvent, anti-knock compound
methyl chloride	---	100	100	---	CNS depressant	CNS effects	4.8atm	-12F	extractant, solvent used in organic chemical manufacture
methlene chloride		50[1]	500	---	narcotic	---	350mm	104F	solvent
perchloroethylene	5	100	100	mild eye, nose and throat irritant	CNS depressant may cause hepatic injury	---	14mm	250F	solvent, dry cleaning
toluene	37	100	200	eye, respiratory and skin irritant	CNS depressant	---	22mm	231F	feed for chemical production, solvents fuel constituent
1,1,1-trichloroethane	180	350	350	eye and dermal irritant	narcotic	---	100mm	165F	industrial solvent
trichloroethylene	20	50[1]	100	eye, nose and throat irritant	CNS depressant	---	58mm	188F	degreasing solvent
vinyl chloride	---	5[1]	1	skin irritant	CNS depressant	strong correlation with CNS, respiratory, hepatic, and lymphatic cancer in humans	2600mm[3]	6.98F	used in the manufacture of polyvinylchloride, solvent, and chemical manufacturing intermediate

[1] Proposed TLV - Threshold Limit Value

[2] at 20 C mm Hg

[3] at 25 C mm Hg

[4] Source: NIOSH, Interim Reports 1 & 2, Health Hazards Reports, 1981, Unpublished

[5] 100 to 800 ppb concentrations were measured above the aeration basin of a WWTP. Source: Personal conversation, Paul Wagner - EPA/MERL [illegible]

TABLE 3-11

VOLATILES WITH HIGHEST INFLUENT CONCENTRATIONS

Organic Compound	Average (in ug/l)	Percent of Time Detected
Benzene	585	14.4
Chloroform	516	94.1
1,2-Dichloride	223	87.3
Methylchloride	218	97.9
Methlene Chloride	727	94.9
Perchloroethylene	77	92.4
Toluene	46	7.2
1,1,1-Trichloroethane	21	13.1
Trichloroethylene	21	59.3
Vinyl Chloride	17	90.3

SOURCE: EPA 40 POTW Study

Recently in Louisville, Kentucky, a catalytic converter of an automobile ignited explosive gases in a manhole causing significant damage to the sewer. This is only an example of what types of accidents can occur with the presence of volatile organics in a wastewater treatment facility. There are also case histories of sewer workers who have been overcome in manholes by toxic volatile pollutants, even after protecting themselves against normal sewer gas hazards. (See Appendix B6-1)

Heavy metals such as lead, mercury, cadmium, chromium, and nickel, from industrial sources are also contained in the wastewaters which reach the POTW. In the aeration basin of a typical sewage treatment plant, the heavy metals may be absorbed onto particulate matter and emitted to the air as aerosols. These metal-containing aerosols can be inhaled by workers during POTW operations. The toxicological properties and exposure criteria for heavy metals commonly found in POTW influent are shown in Table 3-12. The general provisions of the 403 program are meant to control some of these problems.

3.4.2 Air Pollution

Approximately 400 POTWs incinerate or pyrolyze 1,067,432 tons of municipal sludge per year. This number is continually increasing as landfill space decreases and incinerator technology expands and becomes more versatile in meeting the municipalities' needs.

During the combustion of municipal sludges, emissions to the atmosphere occur in the form of particulates, toxic organics and metals. The majority of the sludge which is incinerated is generated at secondary level treatment facilities. These plants generally remove 75 percent of toxic metal pollutants which accumulate in the sludge. In the incineration or pyrolytic process, a number of chemical processes can occur, allowing for emission to the atmosphere of many complex organmetallic and hydrocarbon compounds. Many of these emissions are known health hazards.

TABLE 3-12

Exposure Criteria for Heavy Metals

Metals	Concentrations (in mg/m^3)			Health Effects			Industrial Use
	actually measured	TLV	PEL	local-acute	systemic-acute	chronic	
Cadmium	1.57×10^{-5}	.05	dust: 0.2 fume: 0.1	respiratory irritant	respiratory injury, lung damage	suspected carcinogen, kidney damage	protective coating applied by electroplating
Chromium	3×10^{-5}	0.5	0.1	tracheo-bronchial irritant	---	carcinogen of lung and nasal cavity (hexavalent chromium form only)	"
Copper	2.1×10^{-4}	0.1	fume: 0.1 dust: 1.0	skin irritant	respiratory tract irritant	---	electrical industry, pesticides
Lead	6.1×10^{-4}	0.15	0.05	---	---	kidney damage, CNS damage	battery manufacture, antiknock compound
Nickel	1×10^{-5}	1.0	1.0	skin sensitizer	---	carcinogen of nasal cavity, lungs, paranasal sinus	electroplating, metal working
Silver	---	0.01	0.01	---	grayish pigmentation of skin and membranes	---	photographic films, jewelry, catalysts

*These measurements were taken at an activated sludge plant.

Source: Northrop, el al, 1980. Health Effects of Aerosols Emitted from an Activated Sludge Plant. Wastewater Aerosols and Disease, EPA Health Effects Research Laboratory. EPA-600/9-80-028.

As time progresses a number of things are occuring which will only increase the atmospheric loading of air pollutants. These items are:

- Increase in the number of POTWs that are incinerating their sludge
- Increase in POTWs that meet secondary treatment; this results in a proportional increase of toxics in municipal sludge.

Air pollution is not considered in the model although the amount of volatilization of organics is calculated.

3.4.3 Groundwater

Fifty percent of the nation's groundwater is used as a drinking water source. Contamination of these groundwater sources has become an increased concern in recent years. Wastewater treatment facilities are often sources of groundwater contamination. Approximately five percent of the total volume of flow which passes through a POTW is estimated to exfiltrate, much of it to groundwater sources. Exfiltration accounts for approximately 750 million gallons per day from broken pipes and cracked liners in holding ponds.

The rate and manner in which a pollutant moves from the source to the groundwater depends on several complex physical processes. However, many of the metals and organics found in wastewater generally migrate more rapidly through soil to a groundwater source.

POTWs as a source of groundwater contamination becomes more critical in light of the trend of industries to discharge more wastewater to POTWs while POTWs are not increasing their capacity to handle these increased volumes or to remove toxic pollutants. Overall, however, little attention has been given to this problem and data does not exist to quantify the extent to which industrial pretreatment will mitigate groundwater contamination. Groundwater impacts are not considered in the modeling exercise.

3.5 SUMMARY -- The Need for Control of Industrial Discharges to POTWs

The extent of upsets and NPDES violations at POTWs indicate a need for municipalities to identify and survey wastewater sources and take other measures to characterize their operational and environmental problems. This need is evident for several reasons.

First, a significant number of the POTWs experience upset and bypass problems on a persistent basis. The following findings demonstrate this problem:

- The O&M file reports that 72 percent of POTWs receiving industrial wastes experience operation and maintenance problems associated with that waste.
- The 77 POTW Study reports that 84 percent of POTWs experiencing process upsets do so because of industrial discharge to the POTW.
- In the literative case studies, 43 percent of the municipalities cite protection of the POTW as the key motivation for implementing a pretreatment program.

Second, in many instances POTWs do not know if pollutants are passing through the plant or what causes interferences episodes. Moreover, many plants have not measured contamination levels of their sludges. Likewise, until recently very few POTWs had precisely identified the industries discharging to their treatment facilities. The 132 Study indicates that 36 percent of the POTWs had not conducted an industrial waste survey (IWS). Of those that had conducted an IWS, 73 percent reported that they have taken action toward establishing a formal pretreatment program in accordance with the federal regulations. A majority of cities which have conducted an IWS completed it within the last three years, suggesting that federal pretreatment program was the motivation.

The 132 Study contains other data suggesting that many municipalities and POTWs have not examined the extent of environmental problems at POTWs. Sixty-six percent of the POTWs studied do not monitor for heavy metals in their influent and 69 percent do not monitor for the presence of toxic organics. The 77 POTW Study reinforces these findings. Sixty-eight percent of these POTWs have no industrial monitoring programs. Of those that do monitor, only 12 percent monitor for metals and 1 percent for toxic organics. Finally, 30 percent do not have knowledge of the quality of their sludge.

These two findings indicate that many POTWs without pretreatment programs are potentially subject to industrial - related problems, yet do not know the source or extent of their problems. These findings indicate the need for a program, like the General Provisions of the 403 program, which provides a system for identifying industrial dischargers through waste surveys, monitoring and control of problem discharges.

Toxic discharges from many POTWs are significant, based on the results of the modeling exercises. Key findings about toxics from the model are:

- Almost half of the POTWs exceed water quality standards for at least one pollutant assuming the POTW is the only discharge to the stream.
- Exceedances of water quality criteria for cadmium and silver occur with the greatest frequency but cyanide, lead, and copper can also present water quality problems.
- The impact of the discharge from POTWs on stream water quality depends on local water quality conditions, stream size and the impact of other dischargers to that stream.

The number of water quality exceedances reported by the model represent a minimum number that would be anticipated from POTW discharges because of the assumptions used in developing the model. The lack of data on ambient stream quality, dilution ratios and the presence of other dischargers to stream segments also serve to decrease the occurance of exceedances estimated by the model.

4. ANALYSIS OF PRETREATMENT OPTIONS

This chapter evaluates a wide range of pretreatment options designed to address the key findings in Chapter 3. These findings are:

- In the absence of any additional pretreatment requirements, POTWs are relatively significant dischargers of toxics, contributing about 60% of the total discharge of toxics by indirect and direct discharges.
- in the absence of any additional pretreatment requirements, toxic water quality problems resulting from POTW effluent discharges for at least one of the nine pollutants analyzed are expected for about 46% of the POTWs and 19% for at least two pollutants.
- in almost all cases where water quality problems are expected, POTWs are likely to need more toxic effluent reduction than can be achieved by categorical pretreatment standards for industry alone; and
- upsets, bypass, interference and sludge contamination are site-specific problems with site-specific solutions.

All of the options analyzed (except for the no program option — guidance only) use the same mechanism to identify, prevent or remedy problems of upset, bypass, interference and sludge contamination. Each option requires municipalities to implement basic industrial waste control programs along the lines envisioned in the General Provisions of the 403 Regulations (hereinafter referred to as the "basic" 403 program requirement). The basic 403 program calls for a minimal and flexible effort by localities to identify industrial users, develop effluent limits for problem discharges and perform permitting, monitoring and enforcement activities to reduce industrial discharges harmful to the POTW or the environment.

The options differ in their strategy for reducing the pass-through of industrial toxic pollutants into the POTWs' receiving waters. The most significant difference between the options with regard to reducing pass-through is whether they are "targeted" or "untargeted." "Targeted" options require controls only where they are needed to achieve water quality; and "untargeted" options require uniform controls regardless of the status of local water quality problems. This analysis has quantified the cost and environmental differences between targeted and untargeted options. To quantify the differences, the POTW model was used to estimate the cost of each option to industry and to municipalities. In addition, the POTW model was used to quantify a number of indicators of environmental benefits, including the amounts of toxic pollution removed and the extent to which each option may reduce water quality violations. Finally, some of the benefits associated with the options have been monetized.

There are other differences between the options that can have a less significant effect on cost or environmental impacts, but have important programmatic implications. These differences include whether the control point is at the industrial level or at the POTW, whether the requirements are technology-based or water quality-based, the level of federal involvement and the reliance on local initiative. The significance of these differences among the options is qualitatively discussed. However, it was not possible within the time frame and resources of this study to quantify the cost and environmental impacts of these differences. For example, it was not possible to quantify the potential cost savings associated with regulating the POTW instead of regulating the industries discharging into the POTW. This cost saving is likely to be small compared to the cost savings associated with targeting requirements.

This chapter also identifies key implementation and design issues. These include issues regarding the technical feasibility of developing technology-based toxic limits for POTWs, water quality waivers and water quality-based limits. It was not feasible within the time and resource constraints of this study to develop approaches for overcoming the problems identified.

Finally, there are additional variations to the options that were not analyzed. This does not mean that these potential improvements are not important, but rather that they were less significant considerations from either an impact or a programmatic standpoint than the design parameters identified above. For example, two additional potential improvements for the options that are based on categorical standards include: removal credits allowing industry to meet less stringent pretreatment standards to the extent that the POTW provides removal; and equivalency waivers (or grandfathering) for those POTWs whose existing program is designed differently from federal requirements but has essentially the same effect. While both of these potential improvements will likely result in cost savings to either industry or to POTWs, they are likely to be small compared to the cost differences between targeted and untargeted options. Further, these modifications are adjustments to the existing program rather than program alternatives.

This chapter is organized as follows:

- Section 1 describes the key design choices for the options.
- Section 2 describes the options that have been analyzed.
- Section 3 discusses the key differences and similarities between the options.
- Section 4 presents the environmental impact of each of the options.
- Section 5 presents the options' costs and cost-effectiveness.
- Section 6 discusses the benefits of the options.
- Section 7 discusses feasibility and design issues of the options.
- Section 8 discusses other considerations such as administrative issues.

4.1 KEY DESIGN CHOICES

There are four key design choices for the options analyzed in this report:

- Targeted vs. untargeted requirements
- Technology based-standards versus water quality based standards
- Regulation of industry vs. regulation of POTWs
- Presumptive federal requirements vs. back-up federal requirements

These design features are introduced below and discussed in greater detail later in this chapter.

4.1.1 Targeted Versus Untargeted Requirements

Targeted options require control actions only where there are water quality problems, whereas options that are untargeted require control actions regardless of local environmental conditions. All options with water quality-based standards are targeted. Options with technology-based standards are untargeted unless they include a water quality waiver.

By definition, targeted options should be more cost-effective than untargeted options. However, targeted options may be technically more difficult and expensive to implement and may require greater federal involvement than do untargeted options. As a result, targeted options may not be as effective in the near term as untargeted options.

4.1.2 Technology Based-Requirements Versus Water Quality-Based Requirements

Technology-based requirements are typically uniform for categories of dischargers and require that certain control levels be achieved regardless of the water quality of the receiving waters. If the objective is to achieve water quality, then these standards can result in overcontrol or undercontrol.

In cases where the full control levels are not necessary to achieve water quality, overcontrol can be avoided by providing for waivers. However, in cases where there is undercontrol, technology-based requirements alone will be inadequate to achieve the desired water quality.

Ideally, water quality-based standards should never overcontrol or undercontrol. However, they are typically more difficult to develop, requiring more resources and expertise than technology based-standards. In addition, they may require more time to be effective.

4.1.3 Regulation of Industry Versus Regulation of POTWs

Regulation of the POTW provides the opportunity for the POTW to meet its effluent limitations (whether water quality-based or technology-based) in the most cost-effective manner. This could include the reduction of pollution discharges from nonindustrial sources, the enhancement of POTW treatment capabilities, the use of categorical pretreatment standards for industrial sources, and the use of economic approaches such as effluent charges for industrial dischargers.

Direct federal regulation of industry reduces the options that POTWs may consider in addressing their water quality problems. Therefore, federal regulation of POTWs should be more cost-effective than directly regulating individual industries. However, as discussed later in this chapter, regulations for POTWs can be technically more difficult to develop than regulations for industry.

4.1.4 Presumptive Versus Back-up Federal Requirements

Presumptive federal requirements establish specific effluent limitations and deadlines. Federal back-up requirements allow POTWs to identify and solve their problems without federal intervention, but provide for specific federal intervention if the problems remain after a set period of time. With guidance, there is only information provided with no presumptive federal requirement and no federal back-up.

4.2 OPTIONS EVALUATED

Nine options are evaluated in this report. These options were selected to represent the most important combinations of the key design features. The starting point for each of the options (except for Guidance Only) is the basic 403 program. The options differ in the way they deal with the pass-through of industrial toxic discharges is dealt with.

The options and the circumstances in which each option is best suited are described below.

4.2.1. The Existing Program

This option requires full implementation of the existing program as described in Chapter 1 and assumes for the purposes of analysis, that this has been accomplished. Two thousand (2000) municipalities are required to implement a basic 403 program to control industrial wastes and must apply and enforce categorical pretreatment standards for all 34 industries discharging any of the 129 priority pollutants. Under this option, municipalities are assigned the lead role in implementing and enforcing pretreatment standards. NPDES States may also play a substantial role if they chose. Otherwise, the federal government will oversee compliance efforts. While the administration of this approach is shared by all levels of government, the federal government is responsible for the development and promulgation of technology-based toxic pretreatment standards for industry, thereby creating national uniformity. However, the pretreatment requirements may be reduced where municipalities apply for removal credits for industry where POTW removal efficiencies are high enough to protect water and sludge quality. [For purposes of this analysis, the impact of removal credits on the cost to industry or on water quality was not evaluated.] Thus, the key differentiating feature of this option is the control of pass-through of toxics by nationally uniform, technology-based standards applied to all indirect dischargers within industrial categories by all POTWs receiving regulated wastes.

This approach is most applicable if it is believed 1) that uniform industrial performance standards are needed because toxic pollutants from industry are a significant problem to any POTW receiving them, and 2) that the pass-through of toxic pollutants should be reduced regardless of the status of local water quality.

4.2.2 The Existing Program, But Reduced Scope

This option requires the basic 403 program for the 2000 municipalities but categorical standards would be developed only for selected industries. Alternatively, effluent limits might be developed for selected problem pollutants such as specific heavy metals (cadmium was shown to be the major cause of water quality exceedances in Chapter 3) or cyanide. Categorical standards for the remaining industries would be published as guidance. While the administrative scheme would be the same as the existing program, the administrative burden would be reduced for all three levels of government. This interim analysis has focused on the impact of using categorical standards for metal finishers only because metal finishers typically account for over 56 percent of the metals loadings to POTWs.

The rationale for this option is identical to Option 1, but a majority of the toxic problems at POTWs are attributed to discharges from the metal finishing industry. Thus, by regulating that industry alone, much of the environmental problems caused by indirect dischargers could be abated.

4.2.3 Technology-Based Limits for POTWs

In addition to requiring basic 403 programs to protect POTWs from industry-caused problems, this option controls pass-through of toxic pollutants by the application of technology-based performance standards to POTWs. The essence of this option is to impose toxic limits on the end-of-pipe effluent of POTWs while allowing municipalities to select any control strategy they wish in order to comply with the applicable limits. These toxic limits for POTWs would be inserted as a condition in the POTW NPDES permit. Categorical standards would be published as guidance. POTWs could use the guidance to impose industrial effluent limits that would assure compliance with the toxic limits in its NPDES permit. These limits could be established in two ways: 1) the development of case-by-case toxic effluent limitations equivalent to the effect of applying categorical standards or 2) the development of national, uniform toxic effluent limitations. (For quantitative analysis, this analysis assumes that POTW toxic limits would be set to be equivalent to applying categorical standards.) If limits were not met after a fixed period of time, a federal back-up program (such as the existing program) could become effective.

This option shifts the responsibility for controlling toxics entirely to POTWs while enhancing local flexibility. For example, if a municipality wished, it could meet its toxic limits by installing advanced wastewater treatment technologies instead of regulating industrial discharges, or it could implement user charges for industry instead of using categorical pretreatment standards. However, given the increased responsibilities placed with municipalities, financial incentives and/or technical assistance to POTWs may be needed to make this type of program effective.

This strategy relies once again on a national and uniform means of reducing toxics from POTWs but rejects the rationale that categorical pretreatment standards are the most efficient means to control toxic discharges from POTWs.

Instead, it is believed that municipalities are best situated to design cost-effective solutions and that other sources of toxic pollutants coming to POTWs are important. It also assumes that federally toxic limits for POTWs are feasible to develop.

4.2.4 Water Quality-Based Limits for POTWs

This option parallels the preceding option but utilizes a different basis for establishing effluent limits on POTWs. Municipalities are required to acquire basic 403 program capabilities to prevent industry-related operational and environmental problems, but would only be subjected to toxic discharge standards where water quality standards are violated. As with the technology-based performance standard approach, principle responsibility for the pass-through of toxic pollutants from POTWs would be placed with those POTWs and site-specific solutions for toxics reduction could be pursued either at the treatment works or by regulating industry. Limits based on either federal water quality criteria or State water quality standards (where available for toxics) would be used to derive limits for specific POTWs in their NPDES permits. Control of toxics would be required at fewer POTWs, but when necessary, would impose first-line responsibility on the POTW as in the previous option. If State water quality standards were employed, the State role in determining levels of toxic treatment to be achieved would be significantly increased. The federal role would again be as back-up, enforcing categorical pretreatment standards where POTW compliance is inadequate, and potentially providing financial and technical assistance.

This option would be most applicable 1) if uniform technology-based requirements are not believed to be the best approach for solving most water quality problems and 2) as in the previous option, the POTW is believed to be the best control point and is expected to institute whatever pretreatment measures (or any other steps) that are appropriate and cost-effective. However, it is also believed that a federal back-up may be needed in some cases.

4.2.5 Pretreatment Required To Address Documented Problems

This option is essentially the 403 Regulations without mandatory categorical pretreatment standards or other control requirements. Municipalities will be required to develop basic 403 programs to determine whether they have any problems and to implement a locally designed toxic pretreatment program only where necessary to eliminate documented problems at the POTW. These problems would include the problems typically addressed by the basic 403 program but will emphasize violation of water quality standards. However, no specific control technique for toxics would be mandatory. If the municipality is not successful in correcting its particular problems within a specific period of time, the municipality could be required to implement categorical pretreatment standards.

This option would be most applicable where the problems to be addressed are believed to be variable and as a result, uniform requirements of any type are not considered to be the best solution in most cases. As in Option 4, it is believed that locally designed programs are the best way to address problems and that municipalities have sufficient resources to address their problems. Unlike Option 1, it is not believed that presumptive requirements are necessary, although it is felt that federal intervention as a back-up may be needed to ensure that the required steps are taken.

4.2.6 Guidance Only

The 403 Regulations and categorical standards would serve as guidance with no further federal involvement. This option is most applicable where municipalities have the motivation and resources to solve their own problems, and only require guidance to do so.

4.2.7 Waivers

The use of waivers is not a stand-alone approach, but is used in conjunction with the other options. The use of waivers (instead of changes in regulations or the development of more complex regulations) is especially appropriate where the problems to be addressed are not believed to be widespread.

There are a number of different types of waivers that could be considered. The existing program includes two major waiver mechanisms for industrial dischargers: 1) removal credits allow industrial dischargers to meet less stringent pretreatment levels to the extent that complementary removals are achieved by the POTW and 2) variances from pretreatment requirements are provided in those instances where the industrial discharger is fundamentally different (from a pretreatment standpoint) than the other firms in the same industrial category. Additional waivers for some or all of the requirements of the existing program (or any other option) could be granted where POTWs show that: 1) additional measures are not needed to achieve water quality or 2) the existing POTW program is equivalent to the national program.

This study has evaluated waivers that apply in those cases where the municipality demonstrates that the full requirements are not needed to achieve water quality. These waivers would be most applicable for options with technology-based requirements (such as Options 1, 2, and 3) and, as shown later in this chapter, have significant cost implications. This study includes Options 1, 2 and 3 with waivers as three separate options in addition to the six options described above.

4.3 SIMILARITIES AND DIFFERENCES BETWEEN THE OPTIONS

Many of these options will have similar effects and costs, differing primarily in terms of their administration or the degree of federal involvement.

As a result, it was only necessary to specifically model the environmental and cost impacts of some of the options because the same outputs could be used to fully or partially characterize the impacts of the remaining options. This section highlights the key similarities and differences among the options, and the extent to which some options could be considered to have equivalent effects for the purpose of using model outputs.

4.3.1 The Basic 403 Program

The basic 403 program (the general provisions of the 403 regulations without categorical standards) is the starting point for every option except for guidance. There are two reasons for this. First, the general provisions are the only means by which some problems are specifically addressed in the options. These problems, described in Chapter 3, include: upsets, bypass, sludge disposal problems, worker health and safety. The basic 403 program also encourages municipalities to address toxic problems resulting from pass through. The general provisions of the 403 regulations appeared to be the most cost-effective approach to these problems since they only require that problems be identified and that locally designed solutions be implemented.

Second, many of the options contain a federal back-up that allows federal implementation and enforcement of national standards if the POTW fails to solve its problems or if it fails to implement or enforce a required national program. The current 403 regulations include provision for federal back-up. However, if federal back-up is not desired, any option could be revised to exclude it. Similarly, mechanisms other than the 403 regulations could be used to provide federal back-up if it is desired.

4.3.2 Comparison of Key Design Features

Table 4-1 provides a summary listing of the options that are analyzed in this report. Waivers have been added to Options 1, 2, and 3 to provide three additional options (1b, 2b, and 3b) for a total of nine options.

TABLE 4-1

SUMMARY OF OPTIONS ANALYZED

	OPTION	TARGETED*	TYPE OF STANDARD}	CONTROL POINT	FEDERAL REQUIREMENTS
1.a	Existing Program	NO	TECH-BASED	INDUSTRY	PRESUMPTIVE
1.b.	1.a. with waiver	YES	TECH-BASED	INDUSTRY	PRESUMPTIVE
2.a	Existing Program, Reduced Scope{	NO	TECH-BASED	INDUSTRY	PRESUMPTIVE
2.b.	2.a. with waiver	YES	TECH-BASED	INDUSTRY	PRESUMPTIVE
3.a.	Tech-Based Limits for POTW	NO	TECH-BASED	POTW	PRESUMPTIVE#
3.b.	3.a. with waiver	YES	TECH-BASED	POTW	PRESUMPTIVE#
4.	Water Quality Limits for POTW	YES	WQ-BASED	POTW	PRESUMPTIVE#
5.	Local Program for Documented Problems	YES	WQ-BASED	POTW	BACK-UP OR NONE
6.	Guidance Only	YES	N/A	N/A	NONE

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* Targeted programs require action only where there is a local need.

} Technology-based or water quality-based standards.

{ Controls metal finishes only. Assume all POTWs have metal finishes.

Could also include federal back-up, such as categorical pretreatment standards for industry, if the presumptive requirements are not met.

As can be seen in Table 4-1, the options cover a wide range of combinations of the key design choices. Nevertheless, as discussed below, many of the options can have similar costs and environmental impacts even though they differ in terms of the key design features.

4.3.2.1 Option 1 versus Option 3

Option 1 (the existing program) would be equivalent to Option 3 (technology based toxic standards for POTWs), except that Option 3 transfers responsibility to the POTW, increases the POTW's implementation costs, but allows localities the opportunity to develop local, cost-effective solutions. Both of these options could achieve controls in excess of those needed to achieve water quality standards; similarly both of these options could be inadequate to achieve water quality standards. If Option 1 (the existing program) were combined with a waiver that allowed substitution of equivalent programs, then Option 1 would be entirely equivalent to Option 3 (this type of waiver has been termed "grandfathering").

4.3.2.2 Option 4 versus Option 5

Option 4 addresses all of the problems covered in the other options, but uses the presumptive application of limitations to ensure that water quality standards are met. Option 5 (pretreatment to address documented problems) also addresses all of the problems, but relies on local initiative to solve the problems and provides for a federal back-up if the municipality fails to take adequate steps.

4.3.2.3 Options 1 & 3 versus Option 4 & 5

Option 1 (the existing program) and Option 3 (technology based toxic standards for POTWs) with water-quality waivers would be equivalent to Option 4 (water quality standards for POTWs) in those cases where the categorical standards are more than adequate to allow POTWs to achieve water quality standards; where technology-based standards are inadequate to achieve water quality standards, then Option 4 would be more stringent. If water quality waivers are not provided for in conjunction with Options 1 and 3 then these options will be more stringent than Option 4 where they provide controls in excess of those needed to achieve water quality.

4.3.3 Costs and Environmental Impacts

This study has estimated the costs associated with the implementation of categorical standards and water quality waivers (Options 1, 1a, 2, and 2a). It was not feasible within the time and resource constraints of this study to estimate the cost of achieving reductions beyond categorical standard levels. Nevertheless, the costs associated with full categorical standards (Options 1 and 1a) represent a useful upper or lower bound for the other options depending on the option analyzed:

- The untargeted options (Options 1 and 3, but not 2) are represented by the costs and environmental impacts of categorical standards (Option 1). However, the cost estimates are probably upper bounds for Option 3, since it is expected that POTWs will be able to achieve their requirements at a lower cost.

- All of the targeted options (Options 1b, 3b, 4, 5 and 6, but not 2a) are represented by the costs and environmental impacts for categorical standards (Option 1b). However, the costs estimates are upper bounds for Option 3a since it is expected that POTWs will be able to achieve their requirements at a lower cost. The cost estimates are likely to be lower bounds for the water quality-based requirements (Options 4, 5 and 6) since, as shown in Chapter 3, the control levels needed to attain water quality for some pollutants often exceed the control levels achieved by categorical standards. However, option 5 (and Option 6) may be further limited by the costs associated with categorical standards (Option 1b), since they are assumed to be the federal back-up where municipalities fail to take adequate action to solve their problems.

4.4 ENVIRONMENTAL EFFECTS OF THE OPTIONS

This section describes the environmental effects of the options. As discussed in Chapter 2, the results for the 2000 POTWs are currently based on modeling the impacts of the options on 1839 POTWs. The remaining 161 POTWs were not included because all of the available information showed that they either had no industrial contribution or that they discharged into other POTWs. Thus, the results for the 1839 POTWs should reasonably represent the total impacts.

This section focuses on the impact of the options on the pass-through of pollutants and the resulting effects on water quality as measured by exceedances.

4.4.1 Bypasses, Interference and Upsets

The impact of the options on reducing the number or severity of bypasses and upsets has not been quantified in the model. Chapter 3 provided a detailed discussion of the prevalence of these problems and their significance. All of the options, except for guidance, ensures that these problems are dealt with because they all include the basic 403 program.

4.4.2 Removal of Pollutants

The environmental effects that have been quantified include: pounds of toxic organics and toxic metals removed, percent reduction of toxic pollutants in POTW effluent, and the percent reduction of toxic contaminants in effluent sludge. These estimates are shown in Table 4-2. Available in Chapter 3 are additional data on incremental consumption of water quality criteria and a comparison of BAT removals with POTW efficiencies.

TABLE 4-2

IMPACT OF THE OPTIONS ON ENVIRONMENTAL RESIDUALS

OPTION		POTWs AFFECTED	ANNUAL TONS REMOVED		PERCENT IMPROVEMENT IN POTW EFFLUENT		PERCENT IMPROVEMENT IN POTW SLUDGE
			ORGANICS	METALS	ORGANICS	METALS	
1.a	Existing Program	1839	36,435	25,820	70%	63%	56%
1.b.	1.a. with waiver	846}	16,760	11,877	70%	63%	<56
2.a	Existing Program, Reduced Scope	1839	0	18,733	0	46	28
2.b.	2.a. with waiver	846}	0	8,617	0	<46	<28
3.a.	Tech-Based Limits for POTW	1839	36,435	25,820	70	63	56
3.b.	3.a. with waiver	846}	16,760	11,877	<70	<63	<56
4.	Water Quality Limits for POTW	846}	N/A	N/A	N/A	N/A	N/A
5.	Local Program for Documented Problems	846}}	<16,760	<11,877	<70	<63	<56
6.	Guidance Only	1839	0-36,435	0-25,820	0-70	0-63	0-56

N/A Not Available

} Assuming no ambient concentration of toxic pollutants.

}} Only includes those options that have water quality problems.
Does not include those POTWs that have upset or bypass problems, but no chronic water problem.

The numbers of POTWs affected strongly influences the volumes of pollutants removed and the total cost of treatment. Where the application of the option does not depend on water quality conditions, then all 1839 of the POTWs are affected. If requirements only apply where there are water quality problems, then the number of POTWs affected is reduced to the model estimate of 846. These estimates are based on the numbers of exceedances as discussed in more detail in Chapter 3 and later in this section.

All of the uniform national programs have the largest impacts on reducing the volume of pollutants discharged into waterbodies. This is primarily because the requirements apply to more POTWs than do the other options. Option 2 (categorical pretreatment standards for metal finishers only) has a relatively significant impact on the reduction of toxic metal discharges as well as an reducing toxic organic discharges. The uniform, national programs also significantly improve (on a percentage basis) the quality of the POTW effluent discharge and the quality of the sludge.

While the options significantly affect the volume of the pass-through of toxic pollutants, the importance of these reductions depends on the resulting impacts to water quality. In the following subsection, the immediate impacts to water quality have been analyzed using exeedences as an indicator. However, there can be important water quality impacts even where there are no immediate exceedances because the reduction in pollutant discharge can lower ambient pollutant levels, facilitating the attainment of water quality objectives downstream. In addition, exceedances are thresholds, and (as discussed later in this chapter) there can be benefits associated with reducing pollution even where there are no exceedances or where exceedances persist in spite of controls.

4.4.3 Effectiveness In Reducing Water Quality Violations

As discussed in Chapter 2, an exceedance is a rough indicator of the possibility that there may be a water quality violation for a pollutant. The baseline analysis indicates that there could be 846 POTWs currently that have at least one exceedance. The estimate of 846 is low because it does not take into account ambient levels of toxics in the receiving water or the contribution to water quality degradation due to upsets or bypass at the POTW. In addition, the normalizing assumptions used in modeling industrial discharge loadings and POTW removal efficiencies also tend to minimize the estimate of water quality exceedances.

Table 4-3 shows the reduction in the number of exceedances due to the application of each of the options. About 61 exceedances are eliminated by most of the options, except for Option 2 (the existing program with categorical standards for metal finishing only) where 50 exceedances are eliminated. It is not known how effective Option 4 (water quality-based limits for POTWs) would be. At least 61 violations would be eliminated through this option; however, there are limits to the extent that exceedances can be reduced through more stringent controls on industry because in many cases non-industrial sources are significant contributors. Since the federal back-up for Option 5 is the application of categorical pretreatment standards, it is assumed that municipalities will reduce at least 61 of the exceedances (as in Option 1).

Sensitivity analysis was performed for a broad range of factors, such as changes in ambient conditions and federal water quality criteria. Even under sensitivity analysis, the ability of the options to reduce the number of exceedances remained stable, indicating that where water quality problems exist they are generally severe.

4.5 COST, COST-EFFECTIVENESS AND BENEFITS

This section first summarizes the cost of the options to industry and to POTWs and then examines the cost-effectiveness of the options. The benefits that are obtained from eliminating exeedences are also discussed. It was not practical to include analysis of economic impacts (such as industrial plant closures) in this report because of data limitations.

TABLE 4-3

EFFECTIVENESS OF THE OPTIONS IN REDUCING EXCEEDANCES}
(Based on a total of 1,839 POTWs)

OPTION	INITIAL}} EXCEEDANCES	EXCEEDANCES ELIMINATED	EXCEEDANCES REMAINING
1.a Existing Program	846	61	785
1.b. 1.a. with waiver	846	61	785
2.a Existing Program, Reduced Scope	846	50	796
2.b. 2.a. with waiver	846	50	796
3.a. Tech-Based Limits for POTW	846	61	785
3.b. 3.a. with waiver	846	61	785
4. Water Quality Limits for POTW	846	>61	<785
5. Local Program for Documented Problems	846	<61{	>>785
6. Guidance Only	846	0-846	

} An exceedance is defined to be when a POTW causes at least one water quality criteria to be surpassed. POTWs causing more than one criteria to be exceeded are still counted only once.

}} It is assumed that there is no ambient concentration of toxic pollutants. If there is an ambient concentration of toxic pollutants, then the number of initial exceedences will be higher. For example, if other sources of pollution account for 50% of the aquatic lifewater of quality criteria, then the initial exceedences would increase from 846 (46%) to 1048 (57%). See Table 3-1.

{ Assumed to be limited to the effectiveness of the federal back-up (Option 1a). However, the actual effectiveness could be as high as for Option 4 depending on the steps taken by the POTWs.

4.5.1 Cost

Table 4-4 shows the total annual compliance cost to industry as a result of each option. The industrial cost is divided into two components: the additional cost of pretreatment and the cost of disposing of the additional hazardous waste that is generated. The total cost depends significantly on the number of POTWs affected by each option. Excluding the Guidance Option, the total annual cost ranges from about 0.5 billion dollars for categorical standards for metal finishers including water quality waivers to about 1.9 billion dollars for the existing program.

The total municipal cost contains two components: the program development cost (a one-time cost) and the annual cost of operating the program. Sludge disposal costs for the POTWs are not affected by the improvement in sludge quality because municipal sludges are not now subject to federal regulations that require more costly disposal. If there were sludge criteria that resulted in more expensive disposal, then some of the options could lower the POTW cost (and possibly the net total cost for both POTWs and industry), potentially significantly affecting the relative cost-effectiveness of the options.

4.5.2 Cost-Effectiveness

Some observations about the cost-effectiveness of the options can be made based on two series of assumptions regarding the effectiveness of the options:

- First, each of the options (other than Option 6, guidance only) includes the general provisions of the 403 program that provide for addressing problems of upsets, bypass, and passthrough. If it can be assumed that each of the eight options is equally effective in implementing these provisions, then these nonquantified environmental benefits are not a factor in differentiating among the options.
- Second, the most relevant environmental difference between the options that can be measured is their effectiveness in reducing exceedances. Use of this measure involves two assumptions: 1) that the benefits of reducing

TABLE 4-4

TOTAL COST OF THE OPTIONS FOR POTWS AND INDUSTRY
(Millions of 1981 dollars)
(Based on a total of 1,839 POTWs)

OPTION	POTW COST		ANNUAL INDUSTRY COST		TOTAL ANNUAL COST
	DEVELOPMENT	ANNUAL	PRE-TREATMENT	SLUDGE	
1.a Existing Program	35-91	51-101	1,292	485	1,829-1,878
1.b. 1.a. with waiver	16-55	23-46	594	223	841-864*
2.a Existing Program, Reduced Scope	35-91	51-101	725	252	1,027-1,077
2.b. 2.a. with waiver	16-55	23-46	334	116	472-495*
3.a. Tech-Based Limits for POTW	35-91	51-101	<1,292	<485	<1,829-1,878
3.b. 3.a. with waiver	16-55	23-46	<594	<223	<841-864*
4. Water Quality Limits for POTW	16-55	23-46	>594	>223	>841-864*
5. Local Program for Documented Problems#	16-55	23-46	<594	<223	<841-864*
6. Guidance Only##	0-55	0-46	0-594	0-223	0-864*

Assumed to be limited to the cost of the federal backup. Actually, the costs could be higher depending on the local programs.

The extent of local action in the absence of a federal backup is not known. While the range reflects a maximum cost equivalent to the existing program with waivers (1.b.), the cost could be higher depending on local action.

* Assumes no ambient toxic pollutant levels.

> pollution discharges where there are no water quality problems are insignificant and 2) that the benefits of reducing pollution discharges even where there are water quality problems are insignificant unless the exceedance is eliminated.

Under these assumptions, the most cost-effective option would be the option with the lowest cost per exceedance eliminated. Thus, those options that require uniform action irrespective of local conditions (untargeted options) are likely to be less cost-effective than those options that take local conditions into account (targeted options). This conclusion is most apparant for Option 1a (the existing program) which requires about one half of the POTWs to implement categorical standards even though they have no exceedances; the result is that it costs twice as much as Option 1b (the existing program with waivers) to have the same effect on exceedances. The cost per exceedance eliminated for all of the options based on categorical standards is shown below.

COST PER EXCEEDANCE ELIMINATED FOR CATEGORICAL STANDARDS
(Millions of Dollars)

	ALL INDUSTRIES	METAL FINISHING ONLY
UNTARGETED	30 - 31	20.5 - 21.5
TARGETED (WAIVERS)	13.8 - 14.2	9.4 - 9.9

On this basis, Option 2a, categorical standards for metal finishing only with water quality waivers appears to be most cost-effective of the options that rely on categorical standards.

It is not possible in this report to analyze the cost-per-exceedance of the water quality-based options because it is not known how many exceedances would be eliminated or what the total cost would be. Presumably, however, the costs would be in line with the benefits because the States would always have the option of downgrading the designated stream use if the costs outweighed the benefits of attaining water quality standards.

The costs per exceedance eliminated for categorical standards may appear to be high because the costs of all of the POTWs affected have been loaded onto the smaller number of POTWs where exceedances are actually eliminated. This is illustrated in Table 4-5A which allocates the total costs for each option into three categories: cases where there are no exceedances in the first place, cases where there are exceedances but they are not eliminated and cases where exceedances are eliminated. As shown in the table, the actual mean cost per exceedance eliminated is about 5 million dollars, and the median cost is 350,000 dollars. Table 4-5B shows the effect that ambient levels of toxics can have on the elimination exceedances and on the incidence of cost across the three categories. For an ambient level of 50%, the number of initial exceedences would increase to 57% from 46% and the number of exceedances eliminated would increase to about 80 from 61. The importance of reducing POTW toxic discharges increases as the ambient levels come down to the aquatic water quality criteria.

Tables 4-5 A and B raise three important questions: 1) to what extent should costs be borne in cases where there are no immediate water quality problems, 2) to what extent should costs be borne in cases where there are immediate water quality problems, but where the problems persist in spite of control measures and 3) is it worth the cost to eliminate the exceedances at all? These questions are discussed in the following section on benefits.

4.6 LOCAL BENEFITS OF PRETREATMENT

This report monetizes some benefits of the pretreatment program. Analysis was first limited to recreation benefits, which past studies have indicated are most important. Because it was not clear how to relate degrees of recreation activity to ambient toxics levels, the analysis was next limited to cases in which all exceedances of federal water quality criteria for toxics were eliminated by control options. The basic assumption is that eliminating exceedances makes valuable recreation uses feasible. Finally, analysis was limited to a

TABLE 4-5A

COST OF THE OPTIONS FOR POTWS EXPERIENCING DIFFERENT WATER QUALITY PROBLEMS*
(Millions of 1981 dollars)

OPTION		TOTAL ANNUAL COST	TOTAL ANNUAL COST FOR POTWS WITH NO EXCEEDANCES	EXCEEDANCES REMAINING	EXCEEDANCES ELIMINATED
1.a	Existing Program	1,829-1,878	988-1,014	531-548	310-316
1.b.	1.a. with waiver	841-864	0	531-548	310-316
2.a	Existing Program, Reduced Scope	1,027-1,077	555-582	218-236	254-259
2.b.	2.a. with waiver	472-495	0	218-236	254-259
3.a.	Tech-Based Limits for POTW	<1,829-1,878	<988-1,014	<531-548	<310-316
3.b.	3.a. with waiver	<841-864	0	<531-548	<310-316
4.	Water Quality Limits for POTW	>841-864	0	>531-548	<310-316
5.	Local Program for Documented Problems#	<841-864	0	<531-548	<310-316
6.	Guidance Only##	0-864	N/A	N/A	N/A

---

* Assumes no ambient toxic pollutant levels.

# Assumed to be limited to the cost of the federal backup. Actually, the costs could be higher depending on the local programs.

## The extent of local action in the absence of a federal backup is not known. While the range reflects a maximum cost equivalent to the existing program with waivers (1.b.), the cost could be higher depending on local action.

TABLE 4-5B

COST OF THE OPTIONS FOR POTWS EXPERIENCING DIFFERENT WATER QUALITY PROBLEMS*

(Millions of 1981 dollars)
(Based on a total of 1,839 POTWs)

OPTION		TOTAL ANNUAL COST	TOTAL ANNUAL COST FOR POTWS WITH		
			NO EXCEEDANCES	EXCEEDANCES REMAINING	EXCEEDANCES+ ELIMINATED
1.a	Existing Program	1,829-1,878	787-808	629-649	413-421
1.b.	1.a. with waiver	1042-1070	0	629-649	413-421
2.a	Existing Program, Reduced Scope	1,027-1,077	n/a	n/a	n/a
2.b.	2.a. with waiver	472-495	n/a	n/a	n/a
3.a.	Tech-Based Limits for POTW	<1,829-1,878	<707-808	<629-649	<413-421
3.b.	3.a. with waiver	<1042-1070	0	<629-649	<413-421
4.	Water Quality Limits for POTW	>1042-1070	0	>629-649	<413-421
5.	Local Program for Documented Problems#	<1042-1070	0	<629-649	<413-421
6.	Guidance Only##	0-1070	N/A	N/A	N/A

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* Assumes no ambient toxic pollutant level of 50% of aquatic life water quality criteria.

Assumed to be limited to the cost of the federal backup. Actually, the costs could be higher depending on the local programs.

The extent of local action in the absence of a federal backup is not known. While the range reflects a maximum cost equivalent to the existing program with waivers (1.b.), the cost could be higher depending on local action.

+ About 80 exceedances eliminated, with an assumed average cost of $5 million per exceedance.

n/a Not Available.

Subsection 4.6.1. below discuss the kinds of benefits that exist, but were not studied in the cases examined in this project. Subsection 4.6.2 presents the results of benefits analysis for the cases and categories of benefits that were examained. These benefits measures are compared to costs for the same cases.

4.6.1 Benefits of Control That Were Not Analyzed

Toxics control is likely to produce benefits in the cases where no exceedances are indicated by the POTW model, and in cases where controls do not eliminate exceedances. Because no attempt is made here to measure or monetize benefits in these cases, it is not known whether these benefits are significant enough to warrant the costs of control in these cases. The significance of four factors that affect benefits in these cases is discussed below.

Toxics control will produce benefits other than recreation benefits; these other kinds of benefits are neglected in this analysis. Examples of neglected benefits include health effects, effects on treatments costs when water is withdrawn for use, and the value placed on cleaner water by those who do not actually use that water for recreation ("nonuser" benefits). Health effects and nonuser benefits may be significant in the case of toxic discharges. If water is used for drinking, health effects will always matter; if not they will be more significant when water is useable for recreation. Nonuser benefits are likely to be more significant when high levels of water quality are already being achieved, because small improvements in very polluted water are not likely to be highly valued by local residents.

Another class of benefits that is neglected here are those that accrue in stream reaches other than the single ones examined for each POTW. Even if exceedances are not eliminated in the stream reach examined, control may contribute to their elimination in down stream segments. Alternatively, control where there are no exceedances may prevent the creation of exceedances by subsequent dischargers. In either case, control may create recreation opportunities in stream segments that were not examined. This class of benefits is likely to be significant. The existence of exceedances is strongly affected by stream and POTW flow, which suggests that background ambient levels may have a significant effect on the ability of treatment program to eliminate exceedances in the real world. The neglect of downstream benefits extends to categories of benefits other than recreation as well.

Recreation benefits that are not monetized here exist in cases where exceedances do not occur or are not eliminated. This analysis treats recreation as a threshold phenomena, when in fact changes in toxic concentrations that do not cross thresholds may induce changes in recreation levels or in the enjoyment people receive from their activities. Some types of boating occur to a significant extent in water where toxics concentrations exceed federal standards; the level of this activity is probably affected to some degree by toxics concentrations. Fishing may also occur in water with toxics exceedances, although the enjoyablity of the experience may be limited if some species are not present, are not edible, or are edible only after unusually careful preparation. This effect is probably most important for waters where exceedances remain. Once all federal standards have been met, it is less likely that improvements in water quality will contribute significantly to recreation values.

Finally, pretreatment programs produce benefits that are unrelated to the discharge of toxic pollutants into receiving waters. By preventing upsets, pretreatment reduces discharges of conventional pollutants. This may create significant benefits, because local authorities may prevent certain uses of water where such uses cannot always be safely undertaken: it is simpler to ban swimming, for example, than to prevent it only when an upset caused pollution event occurs.

4.6.2 Benefits Where Exceedences Are Eliminated

A benefits analysis, described in Chapter 2 and Appendix E, was performed for the majority of the POTWs where exceedances were eliminated. As discussed in Chapter 2, adequate information was available to analyze the water quality impacts for 665 of the 1839 POTWs modeled. The model results were scaled up by the factor 1839/665. For the 665 POTWs, exceedances were eliminated for 22 POTWs. Due to anomalies, the benefits analysis was performed for 17 of the 22 POTWs and compared to the cost of the existing program (Option 1) for each of the 17 POTWs.

Two different approaches were used to estimate the recreation benefits for boating, fishing and swimming. The first approach looks to capacity for boating and fishing use, but ignores the number of potential users in the vicinity of the stream reach affected by the POTW. (This approach fails to measure swimming benefits, but these benefits are believed to be small relative to boating and fishing benefits in most cases.) The second approach looks to population in the counties contiguous to the affected stream reach, but ignores the capacity of the reach to support this volume of potential users.

Because the first approach presumes maximum use and the second adequate capacity, regardless of demand, each will overstate benefits in some situations. Therefore, the table below also reports aggregate benefits based on the lower of the two estimates for each stream reach, as well as reporting the aggregate estimates reached using each approach separately. The total annual costs and total annual benefits are shown below in millions of 1981 dollars:

TOTAL COST	BENEFIT ESTIMATE 1 (based on capacity)	BENEFIT ESTIMATE 2 (based on population)	BENEFIT ESTIMATE 3 (lower of 1 or 2)
$ 86 - 88	$ 43 - 82	$ 84 - 114	$ 33 - 55

It is likely that the best estimate of the value of benefits is provided by Benefit Estimate 3, although this may still be an over-estimation. While aggregate costs appear to be greater than aggregate benefits if this estimate is used, the precision of the costs and benefits estimation methods is probably not sufficient to strongly support such a conclusion.

For Benefit Estimate 3, costs and benefits were substantially identical (i.e., within a factor of 2 of each other) in only three of 17 cases. In five of the remaining cases costs substantially exceeded benefits, and in eight cases benefits substantially exceeded costs. In five cases differences were greater than an order of magnitude -- and in all five of these cases benefits exceeded costs. These cases of very large differences between benefits and costs may indicate that a water quality-based option that results in higher costs than categorical standards to eliminate exceedances may be justified in a number of the 785-796 cases where categorical standards were inadequate. There is also support for an inference that the downgrading of the designated uses for some stream segments may be necessary where the costs for eliminating water quality problems substantially exceed the benefits to be gained.

4.7 FEASIBILITY ISSUES FOR IMPLEMENTING THE OPTIONS

The options have been discussed in terms of their effectiveness, their costs, their cost-effectiveness and their benefits. However, there are additional considerations regarding the feasibility and detailed design of the options that could effect the practicality or the attractiveness of the options. For example, waivers based on water quality can be difficult to design and cumbersome to administer; categorical toxic effluent limits may not be feasible to develop; water quality standards for toxics are difficult to develop as is determining the required effluent limitations needed for direct dischargers to achieve the standards; and implementing Option 5 (Local Program for Documented Problems) will require the development of effective procedures for federal, State, and local interaction. Other implementation issues include: the way in which it would be determined that a local program is equivalent to the national program to qualify for a "grandfather" or "equivalence" waiver and the design of removal credits.

These feasiblity and design issues have not been analyzed in this report. However several of the more significant issues are discussed briefly below: water quality waivers for toxics, POTW toxic effluent limitations, water quality standards for toxics and design issues for Option 5 (Local Program for Documented Problems).

4.7.1 Water Quality Waiver Systems For Toxics

Any waiver system must be able to determine when adequate levels of water quality have been achieved, i.e., when waivers for toxics can be granted without adversely affecting the environment. As indicated below, although much has been learned, information on toxics and toxic effects continues to be limited. In addition, available methods for determining the effects of toxic pollutants on water quality are imprecise at best. More rigorous techniques are not likely to be readily available for several more years.

4.7.1.1 Possible Approaches for a Waiver System

There are several methods that could be used to waive technology-based requirements for toxics where they are determined to be unnecessary to achieve desired water quality levels. All would require time and substantial EPA and State resources to properly administer.

Methods for measuring the effects of a waiver on water quality include performing a waste load allocation (considered to be the most rigorous modeling approach), mixing zone calculations, and bioassay testing. The baseline used to determine whether or not waivers should be granted could be either the achievement of State-specified water quality standards, or where State standards are not yet in place, federally-specified water quality criteria. Regardless of the baseline, there will likely be very difficult economic and equity decisions to be made regarding the allocation of limited waivers among dischargers on a stream segment.

4.7.1.2 Current State of the Art

There is still only limited information concerning toxic pollutants, their effects over time, and their effects in combination with one another. This makes it extremely difficult and costly to perform waste load allocations for toxic pollutants. While waste load allocations are viewed as the best, most comprehensive analysis of toxic effects, EPA estimates that it will be at least 3-5 years before these models are readily available for use for toxics. Even then their reliability will be questionable and they may be unable to take into account long term or synergistic effects of the toxic pollutants. The inadequacy of data on toxics means that the results of mixing zone calculations are also extremely uncertain. While bioassay tests can provide a check of an effluent's acute or immediate toxicity, they are unable to measure long term or chronic toxicity and provide no indication of a pollutant's effects downstream.

Few States have water quality standards in place for toxics, and, in general, States appear reluctant to develop toxic standards. While there are federal water quality criteria in place for most toxics, most States have not adopted them. Therefore, while it is likely that waivers could be applied to more pollutants if federal criteria were used, waivers would be more restrictive than they would be if based on State standards.

Therefore, waivers may be difficult to apply in the near term in order to avoid the installation of controls where they are not needed because of the difficulty of making that determination.

4.7.2 Technology-based Toxic Limits for POTWs

As described earlier in this chapter, technology-based toxic effluent limits for POTWs could be developed in two ways: 1) the development of case-by-case toxic effluent limitations equivalent to the effect of applying categorical standards or 2) the development of national, uniform toxic effluent limitations. Issues regarding the feasibility of these two approaches is discussed below.

Under the first approach, the permit writer would develop toxic effluent limits based on the type of POTW treatment system, amount and type of industrial contribution, and recommended industrial pretreatment limitations. As a result, the toxic effluent limits determined by the permit writer would be the same as those attained by the POTW following the application of categorical standards. This approach would require the development of categorical standards, completion of industrial surveys and estimates of the removal efficiency of the POTW. The major shortcoming of this option is the additional resoucres required to develop the 2,000 effluent limitations and the degree of dependence on the permit writer. If it can be assumed that generating these POTW limitations would be equivalent to developing a direct discharge permit, it could require an additional 32-80 fulltime employees over and above EPA's current resource commitments to pretreatment. Based on EPA estimates, this could cost an additional $1.6-4 million/year (400 permits per year X 20-50 person-days per permit X $50,000 per person per year/250 person days per year).

Technically, the second approach is far more difficult to implement than the first approach. There is only limited data available to develop different effluent limits that reflect the type of POTW treatment and the amount and type of industrial contribution. Available data indicate that the influent to POTWs is highly variable and does not appear to be reliably related to the presence of industrial dischargers alone. As a result, even if better data were available, it would still be difficult to categorize POTWs according to their ability to reliably meet effluent limitations for all toxic pollutants. Because of variability and inconsistent occurences, national limits for toxic organics do not appear to be feasible at all. Effluent limits for certain heavy metals (chromium, copper, nickel, lead, zinc and cadmium) may be possible: of the six heavy metals, high concentrations of chromium, nickel and cadmium in POTW effluents can be traced to industrial dischargers. Since national limits would be set so that all POTWs in a category could achieve them, it is likely that the effluent limits would be set "high" and would in actuality only effect POTWs with high discharges from metals-related industries.

4.7.3 Water Quality-Based Approaches For Toxics

The options represent several possible strategies for reliance on water quality considerations in establishing effluent limitations for toxic pollutants. The success of these approaches depend on the state of the art in developing water quality-based effluent limits and technical capability of the States to administer the program. These issues are extensions of the problems associated with granting water quality waivers.

In addition to the requirement that States have the technical capability to administer such programs, there are two key factors that determine the feasibility of using a water quality-based approach for toxics: knowing how much control is needed (or when to stop controlling); and knowing how to allocate control requirements among dischargers. Traditional water quality approaches rely on threshold ambient levels and the use of models to determine the level of control that is necessary and how this level of control should be distributed among sources. This approach is potentially adaptable to toxics as models and data are improved, but it may require several years before there is adequate improvement. However, this delay may not be so significant when compared with the delays that are occurring in the development of technology-based requirements for some industries under the present program.

As an alternative to traditional approaches, effluent charges or a marketable permit system could be used to induce or allocate controls among sources and bioassay monitoring could be used to determine when to stop requiring further reductions. Although bioassay monitoring does not provide complete assurance that all toxic effects have been accounted for, it may be an acceptable measure for the short term until more rigorous techniques (e.g., waste load allocations) are readily available. In this way, steady reductions of toxic pollutants can be achieved without complex modeling.

4.7.4 Design Variations for Option 5

Each of the options requires careful analysis of a number of design considerations. This discussion uses Option 5, Pretreatment Required To Address Documented Problems, as an example of the number of ways in which a basic option can be designed. The key design decisions are: the criteria for identifying problems, and the local/federal interaction and extent of federal involvement.

Documented problems are most easily specified as violations of permit conditions. These could include NPDES permit violations and violations of available State water quality standards. As new water quality standards are adopted by the State, the POTW would be responsible for achieving them. Additional problems, such as violations of sludge criteria could also be included. These criteria could be very specific or they could be stated in general terms.

Where problems are identified, the POTW could be required to notify EPA immediately. The POTW could also be required to submit a plan for addressing the problem. The plan would include specific actions to be taken by the POTW and specific milestones. The plan could be subject to EPA comment; as an alternative the plan could be subject to EPA approval. As an additional alternative, the POTW could be required to notify EPA if the problem is not solved by a specific time in the future.

If the problems are not resolved according to the schedule submitted by the POTW (or by the deadline established by the federal government), then the POTW could be required to submit a new plan, as above, for remedying the problem. If there is a federal back-up, EPA could elect to activate the back-up requirements. The federal back-up requirements could be categorical pretreatment standards or other requirements developed on a case-by-case basis.

4.8 OTHER CONSIDERATIONS

This section briefly discusses administrative considerations, effectiveness issues and statutory constraints.

4.8.1 Administrative Considerations

The different resource implications and impacts to local and State governments of the water quality-based options have not been analyzed in this report. However, as the federal role declines, there is increasing reliance on local and State governments. While a uniform, national program may be less cost-effective overall on a national basis, the costs to individual municipalities and States for developing individual programs could be higher.

The results of the analysis to date do not provide clear direction regarding the most administratively desirable approaches for federal roles in options that reflect local water quality conditions. There are basically two types of federal involvement for these options. The first type is exemplified by Options 1b, 2b, and 3b, where federal requirements are imposed presumptively but waivers from those requirements are allowed. The second type is exemplified by Options 4 and 5 where the local program is presumed to be adequate but federal requirements stand ready as a back-up if the local program fails to achieve the required goals within an adequate timeframe. Administratively, the first type is easiest to administer if the number of waivers is relatively small and the second type is easier to administer if the number of local programs needed is small. However, the model results indicate that about half of the POTWs would either require variances or local programs. Thus, it is unclear from an administrative standpoint which type of federal involvement would be easiest to implement based on this criteria.

4.8.2 Effectiveness

Most of the options are either federally driven or assumed to have a Federal back-up that ensures that action will be taken on the part of POTWs to address their problems. The options could be designed without a Federal backup. The question of whether or not a federal back-up is needed is not specifically addressed in this study. However, the findings from the study of 132 municipalities reported earlier in this document indicates that the primary reason for the controls now in place at POTWs is federal (or State) requirements.

The issues regarding feasibility that have been raised in this study are important when considering the effectiveness of the options. These feasibility issues are primarily related to timing and resource requirements rather than the absolute effectiveness of the options.

4.8.3 Economic Efficiency/Maximizing Net Benefits

Conceptually, the targeted options are likely to come closer to maximizing net benefits than the untargeted options because they only apply in those cases where controls are needed to achieve water quality standards. In addition, where the cost of achieving the water quality standards exceeds the benefits, the designated uses can be downgraded until local decision-makers believe that the costs and potential benefits have been brought into an acceptable balance. In these cases, the requirements of the targeted approaches would automatically be adjusted to reflect the new water quality standards.

ASSESSMENT OF THE IMPACTS
OF INDUSTRIAL DISCHARGES
ON PUBLICLY OWNED TREATMENT WORKS

APPENDICIES

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INTRODUCTION TO APPENDICES

The appendices provide the details of the many analyses that were performed for the Regulatory Impact Analysis (RIA). Each appendix includes a discussion of its data source, assumptions, and analytical methods, and is a support document for the RIA report.

Appendix A includes background information which resulted in the initiation and development of nationwide pretreatment programs. Consideration is given to the impact of industrial effluents on POTWs' performance, an assessment of Federal laws and regulations, the characteristics of POTWs subject to a pretreatment program, progress made to date by Federal, State and municipal governments toward implementation, and a summary assessment of State regulations affecting industrial waste control at POTWs.

Appendix B contains an in-depth study of technical problems associated with the operation of POTWs. This pretreatment program was developed initially to prevent upset problems caused by industrial waste at a POTW. The appendix reviews studies on POTWs performance, operation and maintenance, presence of toxics, air pollution, and worker health and safety. Funded primarily by U.S.EPA, this review provides a sound basis for evaluating the qualitative impact of the various pretreatment strategies in the main report. The analyses and results from Appendix B also provide background information and a quantitative basis for several key POTW computer model assumptions (see Appendix C).

Appendix C includes the overview, development, program documentation and complete results from a computerized mathematical model constructed to assess the environmental, cost impacts, and benefits of pretreatment program alternatives. The POTW model reviews each of the 2,000 POTWs requiring pretreatment, determines and quantifies the pretreatment options for each, and then aggregates the results to estimate national impacts.

Appendix D assesses the benefits associated with improved water quality. The object is to provide theoretical benchmarks for estimating alternate benefit measures for diverse water uses.

APPENDIX A

RATIONALE FOR PRETREATMENT PROGRAM: BACKGROUND ON POTW PERFORMANCE, LEGAL ASSESSMENT AND STATE AND FEDERAL PROGRAMS SUMMARY

INTRODUCTION

The purpose of Appendix A is to provide background and rationale for the pretreatment program. The appendix is divided into five sections:

- A-1, Impact of Industrial Effluents on POTWs Performance
- A-2, Federal Legal Assessment
- A-3, POTW Demographics
- A-4, Progress Made in the Federal 403 Program
- A-5, Summary Assessment of State Environmental Regulations Affecting Industrial Waste Control at POTWs

The Federal 403 Pretreatment Program was developed in response to the upset, interference, and bypass problems that were associated with industries discharging into POTWs. The Technical Problems Section, A-1, summarizes the typical problems associated with industrial pollutants.

POTW operation and industrial wastewater discharge are primarily regulated under the Clean Water Act (CWA); however, many of the other major environmental acts have authority to regulate various aspects of POTW operations. The Federal Legal section, A-2, provides a brief summary of each of the major environmental acts and highlights their relation to the pretreatment program. The purpose of Section A-2 is to provide a basis for understanding the reasons Congress directed EPA to develop pretreatment regulations and to lay the groundwork for assessing whether other environmental acts have the regulatory authority to carry out the intent of the pretreatment regulations.

Of the 15,000 POTWs in the country, 2,000 are required to have pretreatment programs under the General Pretreatment Regulations. These POTWs are distributed more or less uniformly throughout the U.S. Section A-3 discusses geographic distribution, size, and other characteristics of the 2,000 POTWs.

The Federal 403 Program has been in effect since February 1978. Since then, funds have been spent by government and industry to comply with these regulations. Section A-4 compiles data on the costs of program development and implementation at the municipal, State and Federal level. In addition, it estimates the number of pretreatment programs currently in effect as well as the status of pretreatment program implementation at the 2,000 POTWs.

Section A-5 characterizes the role of the States in instituting environmental controls. It also provides data for assessing likely State initiatives and actions in the absence of a Federal pretreatment program.

A-1. IMPACT OF INDUSTRIAL EFFLUENTS ON POTW'S PERFORMANCE

BACKGROUND

Currently, 26 billion gallons of sewage are generated each day in the United States and discharged to POTWs for treatment and disposal. Of this total flow, 83% consists primarily of biodegradable human waste products from residential and commercial discharges. The remaining 17% (approximately 4.4 billion gallons) of the total flow is attributable to industrial discharges.

The POTWs that receive and treat these wastewaters are designed to remove biodegradable organics, suspended solids, and pathogens, normally using primary and/or secondary treatment to achieve specified performance standards. These performance standards, more commonly referred to as secondary treatment standards, limit the quantity of 5-day biochemical oxygen demand (BOD_5), suspended solids (SS), and pH allowed in the discharge to surface waterways and are enforced through POTW National Pollutant Discharge Elimination System (NPDES) permits.

The unit operations most commonly used to meet secondary treatment standards at POTWs are activated sludge and trickling filter operations. Primary treatment to remove suspended and floating solids is achieved in both operations by gravity settling and/or by chemically aided coagulation/precipitation. Additional BOD_5 and suspended solids (SS) removal is achieved by allowing acclimated microorganisms to convert much of the remaining organic material to food and energy. These organisms are either present in a liquid phase, as in activated sludge, or attached to a growth medium such as rocks or plastics, as in the trickling filter operation.

The constituents including screenings, grit, scum and sludge removed by these operations are important waste products of the treatment process. The resulting sludge is usually in the form of a liquid or a semisolid liquid, which typically contains 0.25 to 12% solids. The sludge is usually thickened, and it is then stabilized to (1) reduce pathogens, (2) eliminate offensive odors, and (3) inhibit, reduce, or eliminate the potential for putrefaction

(Metcalf and Eddy 1972). The technologies currently available for sludge stabilization include (1) chlorine oxidation, (2) lime stabilization, (3) heat treatment, (4) anaerobic digestion, and (5) aerobic digestion. The latter two are the most common stabilization processes used at POTWs. Byproducts of these two stabilization processes include water, carbon dioxide, ammonia, methane, and a solid material suitable for disposal. The liquid byproducts can be recycled in a POTW for treatment and the gaseous byproducts can be vented and used for fuel. The solid material is most commonly disposed of in a sanitary landfill or by land spreading.

When properly designed, operated, and maintained, activated sludge and trickling filter unit operations, coupled with aerobic and anaerobic digestion processes, are capable of removing 85% or more of the influent BOD_5 and SS. This is an important consideration to POTWs, which must consistently meet the requirements of its NPDES permit.

However, a recent study has shown that a significant percentage of POTWs designed to meet secondary treatment standards are not consistently meeting their NPDES permit limitations for conventional pollutants and pH (Comptroller General 1980). GAO's random sample of 242 plants in 10 states showed that 87% of the plants were in violation of their permit; 31% were, in GAO's opinion, in serious violation. Additionally, because of water quality considerations, toxic pollutants and nutrients (e.g., heavy metals and phosphate anion) are being regulated through the NPDES permit, and these limitations are also being violated.

One reason given for noncompliance is industrial waste discharges. Industrial waste discharges, although contributing a small percentage of the total flow to POTWs contain significantly higher concentrations of toxic and conventional pollutants than do residential and commercial discharges.

When industrial wastewater is discharged to a POTW, it can contribute to four technical problems: (1) POTW operational problems, (2) POTW sludge disposal problems, (3) POTW effluent water quality problems and (4) POTW worker safety and health. These problems are discussed briefly in the following

SLUDGE MANAGEMENT PROBLEMS

The removal of some toxic industrial pollutants is incidental to the basic POTW treatment operation. Toxic pollutants, particularly heavy metals, enter POTW sludge and can contribute significantly to sludge management problems.

The two primary methods for disposing of POTW sludges are landfilling and landspreading. They are the most widely used methods primarily because they are the easiest and most cost-effective means of disposal. However, if the POTW sludge contains high quantities of toxic pollutants, these methods of disposal may be precluded in order to avoid leaching of toxic pollutants to groundwater or surface water and uptake of heavy metals into crops and the food chain. In turn, this could lead to increased disposal costs because of the need to use alternative disposal methods such as incineration or pyrolysis.

Conversely, toxic pollutants can adversely affect the sludge digestion process. Concentrations of heavy metals in the sludges can increase from 2,000 to 10,000 times higher than the surrounding liquid heavy metal concentration (Feiler 1980, Southworth 1981). If not acclimated to such high concentrations of particular pollutants, the bacterial strain used for sludge digestion can be inhibited or destroyed.

WATER QUALITY PROBLEMS

Many toxic industrial pollutants are inadequately treated at POTWs and consequently pass through the treatment process into the receiving water body. This passthrough of toxic pollutants could jeopardize the attainment of water quality goals and increase the cost of treating drinking water downstream.

Toxic pollutants entering POTWs can also be transformed to another, more toxic pollutant by a particular treatment process. For example, according to Glaze et al. (1975) many new chlorinated organics including chloroform can be formed during the final effluent chlorination.

sections. Specific documentation of these problems can be found in Appendix B.

OPERATIONAL PROBLEMS

Two primary operational problems at POTWs that are caused by industrial waste discharges POTW process upsets or interferences leading to a loss of BOD_5, SS, and pH treatment efficiency and hydraulic and/or organic overloading resulting in reduced treatment efficiency. Each can be controlled by an effective industrial waste pretreatment program.

POTW process upsets or interferences can be caused by continuous or slug discharges of a toxic pollutant that is incompatible with the biological treatment process. Toxic pollutants can retard the normal growth patterns of the microbes that perform the treatment process if the microbes are not acclimated to the pollutants. Additionally, toxic pollutants can destroy the microbial population so that no treatment is provided.

Hydraulic overloads can be caused by one of three conditions: (1) storm events in combined sanitary/stormwater sewer systems, (2) excessive infiltration/inflow, or (3) industrial slug discharges. Hydraulic overloads reduce the detention time within a POTW, thereby reducing removal efficency. Separating combined sewers and relining sewer pipes, although expensive, can solve the first two overload conditions. Slug discharges can be corrected by providing equalization facilities at the source of discharge to more evenly distibute over time the volume and concentration of the industrial discharge.

Organic overloads are normally associated with industries discharging compatible pollutants that are of such strength and volume that the POTW design capacity is exceeded. Pretreatment at the source of the discharge to levels that protect the design loading capacity of the POTW will prevent organic overloads. Industrial pretreatment will also protect any existing unused reserve capacity at the POTW, thereby allowing future growth.

For other toxic pollutants, such as cadmium and zinc, removal efficiencies are low. In both cases, toxic pollutant treatment at a POTW does not attain the level of removal efficiency achieved by the systems typically employed by direct industrial discharges. This passthrough of toxic pollutants may lead to an NPDES permit violation (where toxic effluent limits have been imposed), may result in water quality standard violations, and may jeopardize designated uses of the receiving stream.

POTW Operator Safety and Health

Two additional concerns may be attributed to industrial discharges to POTWs. Some instances of sewage treatment personnel suffering illness and death as a result of exposure to toxic pollutants have been reported. For the most part, personnel affected have been exposed to concentrated toxic chemicals in the anaerobic environment of sewage collection systems. However, industrial slug loads of volatile toxic organic chemicals have also caused worker health and safety problems within POTWs. Finally, the air pollution resulting from the volatilization and aerosolization of toxic pollutants discharged by industry may pose health and environmental risks.

SUMMARY

Industrial discharges of toxic and conventional pollutants have been documented as the important cause of the following problems at POTWs:

- Process interference and upset
- Organic overloading, loss of treatment efficiency, and violation of NPDES permit limitations
- Heavy metal contamination of sludge, limiting available disposal options
- Passthrough of untreated pollutants into receiving streams.

Industrial discharges contribute to these problems because POTWs are primarily designed to remove conventional, not toxic pollutants. Most removal of toxics that occurs is incidental to the treatment process.

A-2 FEDERAL LEGAL ASSESSMENT

The preceeding discussion in Appendix A-1 introduced the kinds of environmental and operational problems that POTWs may experience in conjunction with their treatment of industrial wastes. The following section outlines the legislative and regulatory remedies developed by Congress and EPA to minimize these problems. The principal Federal strategy for prevention of pass-through, sludge contamination, and interference is embodied in the National Pretreatment Program. The history, scope, and workings of its components, the General Pretreatment Regulations and Categorical Pretreatment Standards for New and Existing Sources, are presented to provide a framework for estimating the impacts of this program on States, municipalities, industries and the public.

In addition, other provisions of the Clean Water Act and several other environmental laws affect industrial waste control at POTWs. The procedures, rationales, and interrelationships of the Clean Water Act; the Resource Conservation and Recovery Act; the Safe Drinking Water Act; the Toxic Substances Control Act; the Marine Protection, Research, and Sanctuaries Act; and the Clean Air Act are analyzed to establish the current regulatory environment affecting the National Pretreatment Program. Table A2-I, a summary overview of key statutory and regulatory provisions, is presented at the end of this discussion.

BRIEF LEGISLATIVE AND REGULATORY HISTORY OF THE PRETREATMENT PROGRAM

Because the U.S. Congress was concerned with possible problems associated with indirect dischargers, they included a mechanism, Section 307(b) and 307(c) of the Federal Water Pollution Control Act of 1972, that required the EPA administrator to establish pretreatment standards

> "...to prevent the discharge of any pollutant through treatment works... which pollutant interferes with, passes through or otherwise is incompatible with such works."

The original regulations (40 CFR 128) promulgated under this authority in 1973 required major indirect industrial dischargers to comply with effluent guidelines that define the best practicable treatment for removal of incompatible pollutants. (The regulations anticipated that specific provisions in effluent guidelines would be applicable to pretreatment.) However, technological uncertainties and administrative delays hindered the promulgation of effluent guidelines and pretreatment standards and were one of the bases for the National Resources Defense Council (NRDC) lawsuit against EPA in 1976. As a result of this suit, the toxics Settlement Agreement obligated EPA to develop distinct performance-based pretreatment standards for the same 21 industries and 129 industries and 129 priority pollutants for which "Best Available Technology" (BAT) Standards were to be developed for indirect dischargers. The designation of categorical industries has now been expanded to cover 34 industries. This parallel regulatory approach was incorporated in the Clean Water Act (CWA) Amendments of 1977. To date, two categorical pretreatment standards have been developed, one for the electroplating industry and one for the timber products processing industry. The electroplating standards (40 CFR 413) were first issued on September 7, 1979, have gone through three corrections, and were amended on January 28, 1981. (Certain portions of the electroplating regulations pertaining to integrated facilities as opposed to the smaller job shops are not yet in effect.) The timber products processing pretreatment standards (40 CFR 429) were issued on January 26, 1981 and are currently in effect.

To provide the administrative context and procedures for the enforcement of these categorical pretreatment standards and to otherwise protect POTWs from interference, passthrough, and sludge contamination, the General Pretreatment Regulations (40 CFR 403) were issued on June 26, 1978. Simplifying amendments were issued on January 28, 1981, but their effective date was postponed indefinitely pending submission of a RIA on the National Pretreatment Program to the Office of Management and Budget, as required under Executive Order 12291. Until the outcome of this regulatory review, expected in April of 1982, the 1978 regulations will remain in effect. In the interim, several trade associations, industries, and the NRDC have filed suit, either for review of the amendment package or to challenge its suspension.

SCOPE OF THE PRETREATMENT PROGRAM UNDER 40 CFR 403

The National Pretreatment Program represents an integrated and intergovernmental approach to the control of the environmental and operational problems discussed above. POTWs that have disorders related to industrial waste are afforded regulatory tools and cross-media planning mechanism to develop local solutions. The core of the program requires industries to pretreat wastewater so that discharges to POTWs have a minimal impact on operations and the environment. The General Pretreatment Regulations set forth prohibited discharge standards intended to protect POTWs from nondomestic pollutants causing interference, passthrough, and sludge contamination. General guidance is given for parameters such as acidity, flammability, corrosivity, and heat. Localities are authorized to develop and enforce specific effluent limits for prohibited discharges from industrial users, and additionally to impose limits which ensure compliance by priority pollutant discharges with categorical pretreatment standards.

Enforcement of both prohibited and categorical pretreatment standards is accomplished by a three-tiered administrative scheme. First-line responsibility rests at the local level. POTWs with total flows greater than 5 MGD and that receive wastes from industries subject to national pretreatment standards are required to develop and operate pretreatment programs. Compliance schedules have been written into NPDES permits to ensure that these major POTWs will have pretreatment programs by July 1, 1983. POTWs with total flows less than 5 MGD may also be required to establish pretreatment programs were warranted when special problems associated with industrial influent exist. In either case, NPDES states may relieve localities of program development responsibilities if they choose to operate pretreatment programs at the state level in lieu of operation by municipalities. Connecticut and Vermont have exercised this option. All NPDES states that develop approvable state pretreatment programs will receive full EPA program delegation. EPA Regional Offices will implement pretreatment programs for NPDES states that do not submit state pretreatment program plans and for non-NPDES states. All pretreatment standards including those developed by localities are ultimately enforceable by the Federal Government against industrial users pursuant to Section 309(f) of the Clean Water Act.

In developing pretreatment programs, municipalities survey industrial users and identify the types and magnitudes of industrial pollution in POTW influents. To set prohibited discharge standards interference, passthrough, and sludge contamination problems are analyzed, and effluent limitations are developed to control these problems. All categorical industries discharging to POTWs must be required to comply with effluent limitations set in the applicable Pretreatment Standards for New and Existing Standards. Permitting, monitoring, and enforcement mechanisms are developed to implement these limitations. POTWs then work with existing industrial users to secure the installation of pretreatment technologies or process changes to control excessive discharges. New industrial contributors will be required to incorporate pretreatment technologies into facility design before being allowed to connect to the POTW system. POTWs with high removal efficiencies for regulated pollutants may also pass on removal credits to industrial users, after EPA/State approval. Variances from categorical standards may also be granted by EPA for firms with fundamentally different factors and adjustments approved where toxics are present in industrial user intake water.

In addition to the above standards and mechanisms for regulating industrial pollutants in wastewater discharged to POTWs, the General Pretreatment Regulations encourage localities and states to consider impacts on other environmental media in their pretreatment strategies. In making sludge management decisions, POTWs must comply with the Resource Conservation and Recovery Act (RCRA) and the Clean Air Act (CAA), and a violation of either statute resulting from an industrial discharge constitutes interference under the regulations. Given the profound effects that pretreatment programs have on industrial and municipal sludge generation, POTWs and states are in a position to coordinate water pollution control with local and statewide residual waste planning activities. POTW pretreatment programs must also be consistent with Section 208 water quality management plans.

OTHER CWA PROVISIONS AFFECTING POTWS

Section 301

While the National Pretreatment Program is the focal point for controlling industry-related problems at POTWs, several other CWA provisions affect the posture that POTWs assume in exercising pretreatment authority. As mentioned earlier, existing and new indirect dischargers are subject to pretreatment standards covering 129 toxic pollutants and 34 categorical industries. Toxic limits for the same industries and pollutants are also to be set for direct dischargers to U.S. waters. Pursuant to Sections 301 and 304 of the CWA industries must meet Best Available Technology Economically Achievable (BATEA or BAT) for toxic pollutants by July 1, 1984. An approximate parity must be established between pretreatment standards and BAT standards in terms of ultimate effluent discharged to navigable waters: an indirect discharger's pollutant removal efficiency required by pretreatment standards combined with the subsequent treatment by the POTW should result in approximately the same removal efficiency as that of a direct discharger. If there is an imbalance in the strictness of either control, a shift in discharge status may occur; i.e., if pretreatment requirements are less stringent than direct discharger BAT requirements, direct dischargers might connect to a POTW system or vice versa. The interaction of these two toxic control mechanisms may have a significant impact on POTW wasteloads, operating costs, and rates.

Direct dischargers (industries and POTWs, among others) to the nation's waters must acquire an NPDES permit pursuant to Section 402 of the CWA. These permits, written either by approved NPDES states (33) or the EPA Regions, contain specific effluent limits for point sources to ensure compliance with applicable technology-based performance standards. According to Section 301 of the CWA, standards for industry include meeting Best Practicable Technology (BPT) by 1977 and BCT for conventionals and BAT for toxics by July 1, 1984. Section 301 also mandates performance standards for POTWs: implementation of secondary treatment by 1977 as established by Section 304(d) and Best Practicable Waste Treatment Technology (BPWTT) by 1983. Where effluent guidelines have yet to be developed, as is the case for most toxic pollutants and categorical industries, NPDES permit writers must use Best Engineering Judgement (BEJ) to set permit effluent limits.

Sections 302 and 303

In addition, the NPDES system imposes more stringent water quality-based standards for point sources. Unlike the technology-based standards discussed above, which focus on removal technologies, water quality standards are related to the ambient water quality of receiving streams. Standards are set to protect water quality so that the designated uses of stream segments can be maintained. Pursuant to Section 302 of the CWA, EPA may establish effluent limits for a point source (or sources) to protect public water supplies, agricultural and industrial uses, fish and wildlife, and recreational activities. EPA has published water quality criteria for 64 toxic pollutants (45 FR 79318, November 28, 1980). Under Section 303 of the CWA, states are required to develop water quality standards to protect intrastate water uses. If a state fails to submit water quality standards, EPA will set the standards. In addition to technology-based standards, any applicable water quality standard will determine the extent of pollutant reduction required for a point source in the NPDES permit, if more stringent than the technology-based standard.

Sections 402 and 201

An interdependent relationship exists between the National Pretreatment Program and the NPDES permitting system (Section 402 of the CWA). On the one hand, local pretreatment programs are implemented to enable POTWs to meet technology based standards or water quality standards. On the other hand, NPDES permits may be used to compel municipalities to develop pretreatment programs by making pretreatment programs an NPDES permit condition for municipalities needing pretreatment. The NPDES permitting system is a pollution-reduction-forcing process, and local pretreatment programs are an integrated tool for achieving this reduction. Ideally, applying and enforcing conventional and toxic limits in POTW NPDES permits should prevent the passthrough of industrial effluents into national waters. However, the National Pretreatment Program also provides municipalities with a sophisticated regulatory tool and a national mandate to control industrial waste passthrough. Additionally, protection is provided from interference, sludge contamination, and worker injuries, which might not constitute violations of POTW NPDES permits.

Two other provisions of the CWA influence POTW pretreatment programs. Section 403 regulations require the development of pretreatment programs. The construction grants program under Section 201 of the CWA makes the costs incurred in developing such pretreatment programs eligible for 75% Federal funding, thus lessening state and local financial burdens. In fact, recognizing that POTW pretreatment programs protect POTWs, thereby protecting Federal investment in wastewater facilities made under the construction grants program, EPA made the development of a pretreatment program a condition for the award of any grant or modification for sewage treatment plant construction. This requirement was recently eliminated as part of the overall EPA effort to simplify grant processing.

The National Pretreatment Program may also reduce Federal expenditures for the entire construction grants program. Without the Program's standards and procedures for controlling industrial waste problems, POTWs may eventually choose or be forced to install advanced wastewater treatment technologies to meet NPDES effluent limits. Given the dilution of industrial wastes that occurs at POTWs, such systems may be inefficient, in addition to being extremely costly. Current Congressional concern over the return on the Federal investment in Advanced Wastewater Treatment (AWT) plants under the construction grants program suggests that reliance on and enhancement of POTW performance beyond secondary treatment to control industrial wastes may be politically and economically unrealistic.

POTW costs associated with operating POTW pretreatment programs are not eligible for Federal funding, and Section 403 regulations encourage municipalities to recover costs by imposing industrial use charges. States receive grants under Section 106 of the CWA to administer pollution control programs. These funds may also be used to administer state pretreatment programs. Section 205(g) funds may also be used for these purposes.

Section 405

One final section of the CWA Section 405, has a significant impact on state and POTW pretreatment programs and operations. Section 405 requires EPA to establish regulations that provide guidelines for the disposal and utilization of sewage sludges. Section 405 calls on states and/or EPA to regulate this activity in the POTW NPDES permit. In amending the Federal Water Pollution Control Act, Congress tied pretreatment standard removal credits in Section 307 with an ability to comply with the sludge disposal requirements of Section 405. Section 405 in turn invokes the requirements of other statutes and regulations that protect the numerous environmental media affected by the various sludge disposal methods. Under the joint authority of 4004 of RCRA and Section 405 of the CWA, limits have been set for cadmium and polychlorinated byphenyls (PCB's) in solid waste that is intended for application on lands used for producing food-chain crops (40 CFR 257). Entitled "Criteria for the Classification of Solid Waste Disposal Facilities and Practices," these regulations also provide guidelines for the disposal of sludge incinerator ash, sludge in landfills, sludge in surface impoundments, and sludge that is landspread for nonfood-chain application. They also contain guidelines for protecting groundwater, endangered species, flood plains, and surface waters, and for reducing the transport of pathogens. Under Section 405 EPA has also issued a preproposal draft to regulate the distribution and marketing of sludge and sludge products. This consolidated regulation will set standards for the sale of sludge intended for use as fetilizer, or as a soil conditioner. Because pretreatment standards are designed to prevent sludge contamination, they are an integral part of the strategy to assist POTWs in meeting sludge disposal requirements under RCRA and Section 405 of the CWA.

OTHER STATUTES AFFECTING INDUSTRIAL WASTE CONTROL AT POTWS

Other environmental statutes and regulations require POTWs to control the industrial wastes they receive, thereby enhancing the strategic importance of the National Pretreatment Program. The CAA requires POTWs that choose to incinerate or dry their sludge to meet National Ambient Air Quality Standards (NAAQS) and New Source Performance Standards (NSPS) for sulfur dioxides, particulate matter, carbon monoxide, hydrocarbons, nitrogen dioxide, ozone, and lead, and National Emission Standards for Hazardous Air Pollutants (NESHAPS) for mercury. Further, the Toxic Substances Control Act (TSCA) specifies incineration practices for sludges containing certain levels of PCB's. As sludge quality is improved as the result of pretreatment programs, the efforts required to meet air standards should decrease. The absence of controls placed on emissions resulting from the volatization of pollutants within the treatment facility is a noticeable omission from current air regulations.

The ban on ocean dumping of municipal sludges which do not meet stringent disposal criteria, scheduled to take effect in December 1981 under the Marine Protection Research and Sanctuaries Act, has forced municipalities to find alternate sludge disposal methods. The improvement of sludge quality afforded by pretreatment has eased this transition for cities such as Philadelphia.

The Safe Drinking Water Act establishes maximum contaminant levels for substances such as heavy metals in drinking water. POTWs may affect drinking water sources in a number of ways. A considerable portion of the nation's drinking water sources are surface waters into which POTWs discharge. Reducing the toxic chemicals discharged to these waters should ease the water treatment obligations of municipalities. Leaching of toxic pollutants from municipal sludges to groundwater will also be reduced as sludge quality is improved.

A final area lacking any regulatory protection outside the pretreatment program is worker health and safety at the POTW. The Occupational Safety and Health Act specifically exempts national, State, and local governments from its definition of an employer. Thus, POTW workers are not protected from occupationally related health or safety hazards under the Act. Similarly, most state laws do not provide any means for protecting sewage treatment workers from industrial slug loads of toxic chemicals. Thus, in the absence of other worker health and safety protection, the pretreatment program may play an important role in protecting their workers.

TABLE A2-I

STATUTE	REGULATION	SUMMARY	NUMERICAL LIMITS
Clean Water Act			
Section 402	40 CFR 125--NPDES Regulations	Point-source discharges to navigable waters must obtain an NPDES permit. Permits written, either by approved NPDES states or EPA Regions contain specific effluent limits for point sources that ensure compliance with applicable technology-based performance standards and water quality standards.	
Section 303	40 CFR 120--Federal Water Quality Standards	Under Section 303, disposal facilities must meet Federal/state ambient water quality standards, which are based on Federal guidelines and criteria for maximum permissible stream loading of designated pollutants. Aquatic limit is µg/liter based on 24-hr average chronic toxicity with an assumed average hardness of 100 mg/liter where required.	Pollutant / Freshwater Aquatic Limit / Human Health Limit Antimony 1,600 146 Arsenic 440 0.0022 Beryllium 5.3 0.641 Cadmium 0.025 10 Chromium 4,700 1,700 Copper 5.6 1,000 Cyanide 3.5 200 Lead 3.8 50 Mercury 0.00057 0.144 Nickel 96 13.4 Selenium 35 10 Silver 4.1 50 Thallium 40 13 Zinc 47 5,000
Section 301 Section 304	BAT Standards (See Effluent Guidelines Document)	Standards are set for toxic and non-conventional pollutants. Compliance for priority toxic pollutants to be obtained by 7/1/84. For other toxic pollutants identified, compliance required within 3 years of effluent limit promulgation; for non-conventional pollutants, by 7/1/87.	
Section 301(b) Section 304(d)	40 CFR 133 Secondary Treatment Regulations	POTWs are required to meet effluent limitations based on secondary treatment by 1977 and Best Practicable Waste Treatment Technology (BPWTT) by 1983.	Secondary Treatment Pollutant / Limitation BOD 30 mg/liter (30-day mean) TSS 30 mg/liter (30-day mean) pH 6.0 < x <9.0
Section 201(g)(2)(A)	BPWTT Standards (nonexistent to date)		
Section 307	40 CFR 403--General Pretreatment Regulations for Existing and New Sources	General prohibitions applicable to all non-domestic users of a POTW are set forth to prevent interference with POTW operations, pollutant passthrough in violation of POTW NPDES permit, and municipal sludge contamination.	

TABLE A2-1 (Continued)

STATUTE	REGULATION	SUMMARY	NUMERICAL LIMITS
Clean Water Act (cont'd) Section 307 (cont'd)		Administrative mechanism is established to ensure application and enforcement of discharge prohibitions and categorical pretreatment standards.	
		Regulation provides for issuance of construction grants for major POTWs required to establish local pretreatment programs.	
		Mechanisms are provided for tailoring the effluent limits in categorical pretreatment standards to unique circumstances of a particular industrial user.	
Section 307	40 CFR 413--Effluent Guidelines and Standards, Electroplating, Point-Source Category Pretreatment Standards for Existing Sources	The concentration or mass of certain pollutants that may be introduced into POTWs by operations in the electroplating point source category is limited. Standards contain specific numerical limits based on evaluation of available technologies in each industrial subcategory.	
	40 CFR 429--Timber Products Processing Point-Source Category	Discharge of pollutants into navigable waters and POTWs from existing and potential new sources in the timber products industry is limited.	
		Regulations establish BPT, BCT, NSPS, and PSNS standards for some subcategories of the timber products processing point-source category.	
Section 405	40 CFR 257--Criteria for the Classification of Solid Waste Disposal Facilities and Practices (see also RCRA, SDWA)	Sludge disposal facilities must meet criteria for safety, surface water protection, groundwater protection, flood plains, endangered and threatened species, and air quality protection.	
		Facilities comply with maximum contaminant levels in Appendix I of criteria to protect groundwater quality promulgated under the Safe Drinking Water Act (SDWA).	
		If berms or dikes are used to meet flood plain criteria, dredge and fill permits must be obtained if facility is located in a wetland.	
Section 405	Preproposal Draft Released by Office of Water and Waste Management, 5/6/80, on Distribution and Marketing of Sludge Products (40 CFR 258)	The following are being considered for incorporation into regulations on distribution and marketing (40 CFR 258), based on proposal draft: o Manufacturer (firm or POTW that produces, packages, labels finished sludge product) is likely to be regulated.	

TABLE A2-1 (Continued)

STATUTE	REGULATION	SUMMARY	NUMERICAL LIMITS
Clean Water Act (cont'd) Section 405 (cont'd)		o Regulations are likely to deal with sludge fertilizer products and sludge soil conditioners separately, based on nitrogen, moisture contents, end use. o Sludge constituent of the fertilizer product or soil conditioner may require treatment by a process to further reduce pathogens as described in Criteria for the Classification of Solid Waste Disposal Facilities and Practices, Appendix II, Part B. o Sludge fertilizer products may be less stringently regulated than sludge soil conditioners, but may have nitrogen/contaminant limit and labels specifying use instructions. o Controls on sludge soil conditioners and fertilizers may recognize the concept of a "good sludge"; minimum requirements for good sludge and unrestricted use might include - Specific limiting concentrations for contaminants such as cadmium, PCB, lead - Requirement for minimum lime content to protect against heavy metal availability - Adequate stabilization to prevent pathogens, odor - Controlling cadmium/zinc ratio as protection against problems with cadmium in the diet. o Sludges not meeting "good" sludge requirements may be classified into two separate categories by end use - Products for restricted general use--may require sludge producer to include labels or invoices that give user application rates, use instructions. Label may contain warnings which restrict certain usage based on specific contaminant content. - Products for governmental use--to be used under governmental or POTW supervision on publicly-owned land. Product would have maximum concentration limits for specific contaminants. o Sludge producers may be required to analyze sludge for keeping records on levels of - Cadmium - Nitrogen - Lime - Lead - Phosphorus - Other metals - PCB - Potassium (Zn, Cu, Ni)	

TABLE A2-1 (Continued)

STATUTE	REGULATION	SUMMARY	NUMERICAL LIMITS
Clear Water Act (cont'd)			
		They may have to maintain records on method used to reduce pathogens.	
Section 106	40 CFR 35.1500 (Subpart G)	Regulation gives Federal matching grants to states for pollution control programs.	
Section 201	40 CFR 35.900 (Subpart E)	Regulation gives Federal grants for design and construction of municipal treatment works.	
Section 205(g)	40 CFR 35.1000 (Subpart F) 40 CFR 35.1500 (Subpart G)	Regulation provides for the use of portion of state's construction grants allotment for non-construction purposes such as administration of approved permit programs under Sections 402 and 404, and administration of Section 208 statewide wastewater management programs.	
Safe Drinking Water Act	40 CFR 143--National Secondary Drinking Water Regulations	Regulations provide guidelines for contaminants that may adversely affect an esthetic quality of drinking water, i.e., taste, odor, color, appearance, and limits copper and zinc levels in drinking water.	SDWA copper levels: 1.0 mg/liter SDWA zinc levels: 5.0 mg/liter
	40 CFR 257--Criteria for Classification of Solid Waste Disposal Facilities and Practices (derived from 40 CFR 141, National Interim Primary Drinking Water Regulations)	Regulation sets forth maximum contaminant in Appendix I if sludge disposal facilities comply with groundwater criteria.	o Maximum contaminant levels to determine whether facilities comply with groundwater criteria (Appendix I). - Inorganic chemicals: Contaminant — Level (mg/liter) Arsenic 0.05 Barium 1.0 Cadmium 0.010 Chromium 0.05 Lead 0.05 Mercury 0.002 Nitrate (as N) 10.0 Selenium 0.01 Silver 0.05 - Fluoride: Temp. (°F)* — Temp. (°C)* — Level (Mg/liter) 53.7 and below — 12 and below — 2.4 53.8 - 58.3 — 12.1 - 14.6 — 2.2 58.4 - 63.8 — 14.7 - 17.6 — 2.0 63.9 - 70.6 — 17.7 - 21.4 — 1.8 70.7 - 79.2 — 21.5 - 26.2 — 1.6 79.3 - 90.5 — 26.3 - 32.5 — 1.4 *Annual average of max. daily temperature.

TABLE A2-1 (Continued)

STATUTE	REGULATION	SUMMARY	NUMERICAL LIMITS
Safe Drinking Water Act (cont'd)	40 CFR 257 (cont'd)		- Organic Chemicals: Contaminant — Level (mg/liter) Chlorinated hydrocarbons: o Endrin 0.0002 o Lindane 0.004 o Methoxyclor 0.1 o Toxaphene 0.005 Chlorophyoxys: o 2,4-Dichlorophenoxy-acetic acid 0.1 o 2,4,5-TP Selvex 0.01 o Maximum Microbiological Contaminant Levels (coliform bacteria) - Using membrane filter technique: o 4 coliform bacteria per 100 milliliters if one sample taken o 4 coliform bactera per 100 milliliters in more than one sample of all samples analyzed in one month. - Using 5 tube most probable number technique (fermentation tube technique): o If standard portion in 10 milliliters coliform in any five consective samples from well not to be present in 3 or more of the 25 portions. o If standard portion is 100 milliliters coliform in any five consecutive samples from a well not to be present in 5 portion of 5 samples or in more than 15 of the 25 portions. o Maximum contaminant levels of radioactive substances: - Combined Radium-226 and Radium-228 - 5 pC/liter.

TABLE A2-I (Continued)

STATUTE	REGULATION	SUMMARY	NUMERICAL LIMITS
Safe Drinking Water Act (cont'd)	40 CFR 257 (cont'd)		- Gross alpha particle activity (including radium-226 but excluding radon and uranium - 15 pC/liter).
Marine Protection Research and Sanctuaries Act	40 CFR 220 through 229--Ocean Dumping Regulations	Regulates introduction of toxic pollutants into the marine environment, with specific prohibitions on ocean dumping of any material containing cadmium or mercury as other than trace contaminants. Ocean disposal of sewage sludge will be prohibited by 12/31/81 for POTWs not meeting disposal criteria.	
Clean Air Act			
Section 109	40 CFR 50--National Ambient Air Quality Standards (NAAQS)	NAAQS define levels of air quality necessary to protect public health and welfare, setting primary and secondary standards for sulfur oxides, particulates, carbon monoxide, ozone, hydrocarbons, nitrogen dioxide, lead.	Primary NAAQS - Sulfur oxides: a) 80 $\mu g/m^3$ (0.03 ppm) - annual arithmetic mean. b) 365 $\mu g/m^3$ (0.14 ppm) - max 24-hour concentration not to be exceeded more than once/year. Secondary NAAQS - Sulfur oxides: 1300 $\mu g/m^3$ (0.5 ppm) - max 3-hour concentration not to be exceeded more than once/year. Primary NAAQS - Particulates: a) 75 $\mu g/m^3$ - annual geometric mean. b) 260 $\mu g/m^3$ - max 24-hour concentration not to be exceeded more than once/year. Secondary NAAQS - Particulates: a) 60 $\mu g/m^3$ - annual geometric mean as guide to assessing implementation plans for achieving 24-hour standard. b) 150 $\mu g/m^3$ - max 24-hour concentration not to be exceeded more than once/year.

TABLE A2-1 (Continued)

STATUTE	REGULATION	SUMMARY	NUMERICAL LIMITS
Clean Air Act (cont'd) Section 109 (cont'd)			Primary and secondary NAAQS - Carbon monoxide: a) 10 mg/m^3 (9 ppm) - max 8-hour concentration not to be exceeded more than once/year. b) 40 mg/m^3 (35 ppm) - max 1-hour concentration not be exceeded more than once/year. Primary and Secondary NAAQS - Ozone: 235 μg/m^3 (0.12 ppm) - attained when expected number of days/calendar year with max. hourly average concentration above 0.12 ppm is equal to or less than 1.0 as determine by prescribed methods. Primary and Secondary NAAQS - Hydrocarbons: 160 μg/m^3 (0.24 ppm) - max. 3-hour concentration (6 to 9 a.m.) not to be exceeded more than once/year. Primary and Secondary NAAQS - Nitrogen dioxide: 100 μg/m^3 (0.05 ppm) - annual arithmetic mean. Primary and Secondary NAAQS - head and lead compounds: 1.5 μg/m^3 - max. arithmetic mean averaged over a calendar quarter
Section 112	40 CFR 61--National Emission Standards for Hazardous Air Pollutants (NESHAP)	NESHAP restrict emissions of mercury into the atmosphere from sludge incineration, sludge drying, or combined incineration/drying plants.	NESHAP emission level for Mercury: 320 gm per 24-hour period
Section 111	40 CFR 60--New Source Performance Standards (NSPS)	NSPS prescribe performance standards for incinerators, including minimum Federal requirements for particulates discharge, opacity, and monitoring. They apply to incinerators with charging rate $\geq$ 45 metric tons/day (50 tons/day). Owner/operator is required to record daily charging rates, hours of operation.	NSPS prohibits affected facility from discharging into atmosphere any gases with particulates more than 18 gm/dscm (.08 gm/dscf) corrected to 12% CO_2

TABLE A2-1 (Continued)

STATUTE	REGULATION	SUMMARY	NUMERICAL LIMITS
Clean Air Act (cont'd)			
Section 109	40 CFR 51--New Source Review (NSR)	NSR rule under regulation for State Implementation Plans (SIP) sets forth procedures for review and approval of new air pollution sources prior to construction. Also set forth requirements for preventing significant deterioration of air quality.	
Toxic Substances Control Act			
Section 15 Section 16 Section 17	40 CFR 761-PCB Regulations	EPA imposes requirements on facilities disposing of sludge that contains PCBs: Incinerators--recommendations are provided for incinerating sludges containing more than 25 ppm PCB, and incineration disposal practices are specified: o Facilities must comply with combustion criteria. o Rate, quantity of PCBs fed into incinerator must be measured, recorded every 15 minutes. o Automatic stop of PCB flow to incinerator is required if incinerator temperature drops below specified level. o Monitoring requirements are imposed for oxygen, carbon monoxide, carbon dioxide, nitrogen oxides, hydrogen chloride, total chlorinated organics, PCBs, particulates, and for the following combustion products: Oxygen, carbon monoxide, carbon dioxide. o EPA Regional Administrator must approve of incinerator used to dispose of PCB-containing sludge. o Facilities must meet requirements for record-keeping, reporting, trial run.	Incineration: Sludge containing > 25 ppm PCB on dry weight basis (recommended): o Increase incinerator temperature and residence time to destroy at least 95% PCB. Sludge containing ≥ 50 ppm PCB on dry weight basis (required): 1200°C ± 100°C for 2-sec, dwell time with at least 3% excess oxygen in stack gas; or 1600°C ± 100°C for 1.5-sec, dwell time with at least 2% excess oxygen in stack gas. Mass air emissions from incinerator - no more than 0.001 gm PCB/kg (1 ppm) of PCB introduced into incinerator. Combustion efficiency to be at least 99.9%, calculated as: combustion frequency $= C_{CO_2}/C_{CO_2} + C_{CO} \times 100$ C_{CO_2} = Concentration of CO_2 C_{CO} - Concentration of CO

TABLE A2-1 (Continued)

STATUTE	REGULATION	SUMMARY	NUMERICAL LIMITS
Toxic Substances Control Act (cont'd) Section 15 Section 16 Section 17 (cont'd)		Landspreading--Limits are imposed on amount of PCBs that can be added to soil used for food-chain crops. Limits are based on levels imposed by FDA for PCBs in animal feed and milk fat.	Landspreading: Surface application of sludges allowed if sludges contain 10 mg/kg PCB (10 ppm) or less. If sludge contains more than 10 ppm PCBs, must be incorporated into soil rather than spread. If PCB levels are above 50 ppm, 40 CFR 761 regulations apply for disposal procedures.
		Chemical landfills used for PCB disposal--EPA Regional Administrator approval is required, and hydrologic condition requirements; location requirements; sampling, groundwater well monitoring, water analysis, leachate collection requirements; and operation and support facility requirements must be met.	Chemical Landfills used for PCB disposal: Soil parameters - inplace soil 4 ft. thick or compacted soil liner 3 ft. thick. Permeability equal to or less than 1×10^{-7} cm/sec. More than 30% soil passing through #200 sieve. Liquid limit > 30. Plasticity index > 30.
Resource Conservation and Recovery Act			
Section 3004 Section 4004	40 CFR 260 through 265--Hazardous Waste and Consolidated Permit Regulations	Incineration requirements: o Incinerator must be brought to steady-state operating condition before hazardous waste is added. o Waste not previously burned in incinerator must be analyzed for heating value, halogen and sulfur content, lead and mercury content unless written evidence shows their absence. Analysis results must be kept on file. o Followup monitoring/inspections are required for incineration of hazardous wastes: - Instrument monitoring every 15 minutes. - Immediate corrections when required to maintain steady state.	

TABLE A2-1 (Continued)

STATUTE	REGULATION	SUMMARY	NUMERICAL LIMITS
Resource Conservation and Recovery Act Section 3004 Section 4004 (cont'd)	40 CFR 260 through 265 (cont'd)	- Hourly visual observation of emissions for color, opacity. - All equipment to be inspected daily, including emergency and alarm systems. o All wastes to be removed from incinerator at closure. Surface impoundment requirements: o At least 2 feet of freeboard must be maintained to prevent overtopping dyke. Earth dykes to have protective cover to minimize erosion. o Waste analyses, trial tests are required. o Daily freeboard and weekly impoundment inspections are required. o Closure, post-closure requirements must be followed. Landfill requirements: o For general operation, run-on, run-off, and wind dispersal of waste must be controlled. o Exact location map and records of cell contents and waste types must be maintained. o Closure, post-closure requirements: - Closure plan must specify cover function and design and post-closure care. - Plan must address how pollution migration and surface water infiltration will be controlled and erosion prevented. - Plan must be based on type, amount, constituents of waste; waste mobility and expected rate of migration; site location, topography, surrounding land use; climate; cover characteristics; geology, hydrology, soil profiles. o Leachate collection, removal, treatment must be maintained and monitoring. o Gas collection and control to be maintained and monitored.	

TABLE A2-1 (Continued)

STATUTE	REGULATION	SUMMARY	NUMERICAL LIMITS
Resource Conservation and Recovery Act (cont'd) Section 3004 Section 4004 (cont'd)	40 CFR 260 through 265 (cont'd)	o Access must be restricted.	
		o Ignitable, reactive waste must be controlled so that it not hazardous.	
		o Incompatible waste must to be disposed of separately unless special precautions are taken.	
		o Special precautions for leachate control and treatment must be taken and approved containers must be used for liquid wastes.	
		Landspreading requirements:	
		o Waste must be made nonhazardous before use in land treatment.	Cadmium Levels:
		o Waste must be analyzed for concentrations of toxic and other hazardous substances so that maximum concentration limits are not exceeded.	I. a) pH of sludge and soil mixture at time of each sludge contains calmium at concentration of 2 mg/kg dry weight or less.
		o Before food-chain crops can be grown at hazardous waste land treatment facility, it must be demonstrated that arsenic, cadmium, lead, and mercury will not be uptaken by plants or otherwise ingested by food-chain animals; and that concentrations of these substances are not greater than in crops grown on untreated soil in the same region under the same conditions.	b) Annual application of cadmium from sludge does not exceed 0.5 kg/Lectare on land used to produce tobacco, leafy vegetables, root crops for human consumption. For other food chain crops, annual cadmium rate not to exceed:
		o Waste containig cadmium must be treated according to cadmium level guidelines.	Time Period — Annual Cadmium Application Rate
		o Unsaturated zone monitoring plan required.	9/13/79-6/30/84 — 2.0 7/1/84-12/31/86 — 1.25 1/1/87 -- — 0.5
		o Records of application dates, rates, quantities must be kept, along with record of location of each hazardous waste placed in the facility.	c) Cumulative application of cadmium from sludge not to exceed levels in I(a) or I(b) above or in II(a) or II(b) below.
		o Closure, post-closure plans were required; contents should be the same as for landfills.	

TABLE A2-1 (Continued)

<table>
<tr><th>STATUTE</th><th>REGULATION</th><th>SUMMARY</th><th>NUMERICAL LIMITS</th></tr>
<tr><td>Resource Conservation and Recovery Act (cont'd)</td><td>40 CFR 260 through 265 (cont'd)</td><td></td><td></td></tr>
<tr><td>*Section 3004*
Section 4004
(cont'd)</td><td></td><td>o *Special requirements must be followed for* ignitiable, reactive, or incompatible wastes.</td><td>II. a) Soil Cation
<table>
<tr><th>Exchange Capacity (meq/100g)</th><th colspan="2">Max. Cumulative Application kg/ha</th></tr>
<tr><th></th><th>Back-ground Soil pH<6.5</th><th>Back-ground Soil pH<6.5</th></tr>
<tr><td><5</td><td>5</td><td>5</td></tr>
<tr><td>5-15</td><td>5</td><td>10</td></tr>
<tr><td>>15</td><td>5</td><td>20</td></tr>
</table>
b) For soils with background pH less than 6.5, cumulative cadmium application rate does not exceed levels below, provided pH of sludge and soil mixture is adjusted to and maintained at least 6.5 whenever food-chain crops are grown.
<table>
<tr><th>Soil Cation Exchange Capacity (meq/100g)</th><th>Max. Cumulative Application Rate (kg/ha)</th></tr>
<tr><td>< 5</td><td>5</td></tr>
<tr><td>5-15</td><td>10</td></tr>
<tr><td>> 15</td><td>20</td></tr>
</table>
III. a) Only food-chain crop produced is animal feed.

b) pH of sludge and soil mixture is at least 6.5 at time crop is planted or at time sludge is applied, whichever is later, and pH level is maintained whenever food chain crops are grown.

c) Plan for facility demonstrates how animal feed is distributed to preclude human consumption.

d) Future property owners to be notified in record or deep that sludge was high in cadmium and food-chain crops not to be grown.</td></tr>
</table>

TABLE A2-1 (Continued)

STATUTE	REGULATION	SUMMARY	NUMERICAL LIMITS
Resource Conservation and Recovery Act (cont'd)			
Section 1008 Section 4004	40 CFR 257--Criteria for Classification of Solid Waste Disposal Facilities and Practices	Landfills, surface impoundments, landspreading facilities are to comply with Criteria in Appendix II for Processes to Significantly Reduce Pathogens (PSRP) and Processes to Further Reduce Pathogens (PFRP), where applicable.	Appendix IIA - Processes to Significantly Reduce Pathogens: o Aerobic digestion - sludge is agitated with air or oxygen to maintain aerobic conditions for residence times from 60 days at 15°C to 40 days at 20°C. Min. of 3 months necessary, 2 months of which temperatures average above 0°C on daily basis. o Air drying - liquid sludge allowed to drain, dry in drain basins at depth of 9 inches for at least 3 months, 2 months of which temepratures average above 0°C on daily basis. o An aerobic digestion - absence of air at residence time from 60 days at 20°C to 20 days at 35°C to 55°C; volatile solid reduction at least 38%. o Composting - all methods; minimum 40°C for 5 days, with temperature >55°C for at least 4 hours. o Lime stabilization - sufficient lime added to produce pH of 12 after 2 hours. o Other methods acceptable if pathogen reduction = to above. Appendix IIB - Processes to Further Reduce Pathogens: o Composting (within-vessel or aerated pile) - solid waste at operating conditions of 55°C or greater for 3 days. Composting (windrow) - at 55°C or greater for at least 15 days with at least 5 turnings of windrow.

TABLE A2-I (Continued)

STATUTE	REGULATION	SUMMARY	NUMERICAL LIMITS
Resource Conservation and Recovery Act (cont'd)	40 CFR 57 (cont'd)		
Section 1008 Section 4004 (cont'd)			o Heat drying - moisture to be reduced to 10% or less; temperature to reach at least 80°C. o Heat treatment - liquid sludge heated to 180°C for 30 min. o Thermophilic aerobic digestion - liquid sludge agitated with oxygen or air; aerobic conditions maintained for 10 days at 55-60°C, volatile solids reduced at least 38%. o Other methods may acceptable if pathogen reduction = above methods.

A-3. POTW DEMOGRAPHICS

In performing an analysis of the impact of the pretreatment regulations, it is important to understand the characteristics of the POTWs that will be affected by the regulations. To assess how these POTWs are or will be affected by various regulatory options (both technical and procedural), the difference between the POTWs must be understood. This section details how POTWs are characterized according to total and industrial wastewater flow, level of treatment provided, and liquid and sludge disposal techniques.

EPA has identified 2089 individual facilities (2003 POTWs) that are required to develop a pretreatment program under the current regulations. Using EPA's NEEDS Survey (U.S. EPA 1980), all POTWs with a total design flow ≥5 MGD were identified as needing to develop a program. In March 1981, EPA identified the POTWs with <5 MGD total design flow which will require a pretreatment program bringing the total to 2003 POTWs (Diamond, 1981). Of these 2003 POTWs, 36% have design flows ≥ MGD and 64% have design flows <5 MGD. While there are currently 15,250 POTWs in the country, the 2003 POTWs represent systems that treat 81% of the total flow and 91% of the total indusrial flow in the nation. EPA also regards these 2003 POTWs as receiving a majority of the wastewater flow from those categorical industries that have indirect discharges. These 2003 POTWs are geographically distributed across all of EPA's ten regions.

The following tables present the general characteristics of the POTWs in terms of their individual demographics. Table A3-I provides an overview of total and industrial wastewater flows for these POTWs, according to average daily flow. Table A3-II provides similar data, according to the level of treatment provided.

TOTAL FLOW

An analysis of these tables indicate that of the 2003 POTWs, 721 POTWs (36 percent) receive total flows greater than 5 MGD, while 1282 POTWs (64 percent) receive total flows less than 5 MGD. It is important to note that the 1282 POTWs with flows less than 5 MGD only account for about 10 percent of

TABLE A3-I. DISTRIBUTION OF POTWS BY AVERAGE DAILY FLOW

AVER. DAILY FLOW		PERCENT INDUSTRIAL FLOW					
		0-15	15-20	20-30	30-40	40-50	50-100
0-1 MGD	TOTAL FLOW	158	16	19	15	6	17
	INDUSTRIAL FLOW	3	3	4	5	3	12
	NO. OF PLANTS	378	32	37	30	16	34
1-5 MGD	TOTAL FLOW	1,070	134	180	116	113	213
	INDUSTRIAL FLOW	41	23	45	41	51	148
	NO. OF PLANTS	422	59	73	47	42	86
5-20 MGD	TOTAL FLOW	2,717	439	683	567	268	321
	INDUSTRIAL FLOW	123	79	174	200	120	225
	NO. OF PLANTS	292	43	67	53	25	36
20-50 MGD	TOTAL FLOW	1,690	249	628	306	279	526
	INDUSTRIAL FLOW	116	43	157	111	126	356
	NO. OF PLANTS	57	10	19	11	9	17
50-100 MGD	TOTAL FLOW	1,609	313	289	352	293	82
	INDUSTRIAL FLOW	108	56	68	119	128	52
	NO. OF PLANTS	22	5	4	5	4	1
> 100 MGD	TOTAL FLOW	2,966	1,436	1,752	1,153	122	—
	INDUSTRIAL FLOW	192	235	404	394	49	—
	NO. OF PLANTS	18	4	7	6	1	0

TABLE A3-11

DISTRIBUTION OF POTWS BY LEVEL OF TREATMENT

PERCENT INDUSTRIAL FLOW	PRIMARY			SECONDARY			TERTIARY		
	NO. OF PLANTS	TOTAL FLOW (MGD)	INDUSTRIAL FLOW (MGD)	NO. OF PLANTS	TOTAL FLOW (MGD)	INDUSTRIAL FLOW (MGD)	NO. OF PLANTS	TOTAL FLOW (MGD)	INDUSTRIAL FLOW (MGD)
0-15	228	2960	198	914	6831	360	47	418	25
15-20	26	784	131	119	1720	292	8	84	16
20-30	25	761	201	166	2597	628	16	93	23
30-40	16	187	64	131	2201	765	5	119	41
40-50	16	388	167	78	667	297	3	26	12
> 50	32	184	135	133	879	597	9	96	61

the total flow in all 2003 POTWs. Conversely, the 36 POTWs (less than 2 percent) that receive flows greater than 100 MGD account for about 35 percent of the total flow in all 2003 POTWS. 519 POTWs (26 percent) receive flows in the 5-20 MGD range and these account for the majority of the remaining total flow in all of the POTWs. While all of these plants are subject to the pretreatment regulations, a major portion of the total flow is received by a relatively small number of large capacity POTWs.

INDUSTRIAL FLOW

The 2003 POTWs receive a design industrial flow of 4,013 MGD and 60 percent of the POTWs receive 0-15 percent industrial flow. The remaining industrial flow is dispersed fairly equally among the POTWs, with 25 percent of the industrial flow entering those POTWs that each receive less than 20 percent industrial flow. Of the plants with 0-15 percent industrial flow, 41 percent receive less than 5 MGD total flow.

LEVEL OF TREATMENT

Of the 2003 POTWs, 17 percent provide primary treatment, 78 percent provide secondary treatment, and 5 percent provide tertiary treatment. Of the total flow in all POTWs, 25 percent received primary treatment. These primary plants treat 22 percent of the industrial flow.

DISPOSAL OF LIQUID EFFLUENTS

Of the 2003 POTWs, 1,764 discharge liquid effluents to surface waters. This represents 84 percent of the total volume discharged by POTWs. Ocean discharges, account for 12 percent of the total effluent discharged while all other POTW discharge methods combined account for the remaining 4 percent. None of the other discharge methods (drainage ditch, spray irrigation, groundwell injection) account individually for more than 1% of the total.

DISPOSAL OF SLUDGE

Table A3-III lists the annual tons of sludge disposed by five different techniques. Annually, 3.7 million tons are disposed by the 2003 POTWs; 44 percent of that which is disposed comes from secondary and tertiary plants that send sludge to landfils. Because these plants have the capability to

TABLE A3-III

POTW SLUDGE DISPOSAL METHODS
(Tons/Year)

Sludge Disposal Methods	Type of Wastewater Treatment			
	Primary	Secondary	Tertiary	Total
Incineration	193,791	772,915	100,726	1,067,432
Landfill	250,849	1,463,593	164,607	1,870,049
Land Spread	15,445	254,638	30,221	300,304
Trenching	794	18,386	-	19,630
Ocean Dumping	133,567	266,884	-	400,451
Total	594,446	2,776,866	295,554	3,666,866

remove toxic pollutants in significant quantities, the possibility exists that the toxics could accumulate in the sludge in concentration that may make the sludge hazardous and/or difficult to dispose of in a cost/effective manner. Sludge from pirmary treatment facilities can also become significantly contaminated by toxic pollutants if the influent concentration of toxics entering the POTW treatment plant is not controlled. Thus, sludge disposed of in conventional landfills or by land spreading can pose a significant envrionmental problem if the concentration of toxics allowed to accumulate in the sludge is not controlled. Of primary concern are contamination of agricultural land and groundwater.

A-4. STATUS OF THE FEDERAL 403 PROGRAM

INTRODUCTION

Pretreatment is the control of pollutants in nondomestic wastewaters prior to their discharge into POTWs. Pretreatment minimizes or eliminates interference with POTW operations, contamination of POTW sludge, and pass-through of industrial pollutants to the receiving water body. Sections of the Clean Water Act (CWA) of 1977 (Public Law 95-217) specify Federal pretreatment regulations governing existing and new sources discharging to POTWs. The General Pretreatment Regulations promulgated under the authority of the CWA require states and municipalities to develop their own pretreatment programs.

The three authorities responsible for developing and implementing the Pretreatment Program are EPA, State water pollution control agencies, and local POTW management authorities. Appendix A-4 has been broken into three sections which describe the role of each of these authorities and the progress that has been made by each, towards implementing the National Pretreatment Program. Together they provide an overview of the current status of the Federal 403 program.

FEDERAL PROGRAM

EPA Headquarters and Regional Offices are responsible for the Federal portion of the program. The EPA Headquarters conducts program activities, sets policy, develops guidelines, and coordinates those in the regions.

Within the Office of Water Enforcement, the Permits Division has ongoing responsibility for developing and promulgating the General Pretreatment Regulations and is also responsible (in conjunction with the Office of the General Counsel) for the final review and approval of state programs. The Permits Division also develops guidance materials for the national program. Examples of EPA guidance materials are as follows:

- Local Program Development -- "Procedures Manual for Preparing a POTW Pretreatment Program Submission"

- Local Program Review -- "Guidelines for the Review of POTW Pretreatment Program Submissions"
- State Program Development -- "Guidance to State on Implementation of the General Pretreatment Regulations"
- Technology Transfer -- "Industrial Residuals Manual, Vols. I, II, III"
- Public Information -- "Protecting Our Nation's Waters: The National Pretreatment Program"

This Division also provides direct program development assistance to states and POTWs, and enforcement support to the states and regions.

Within the General Pretreatment Regulations developed by the Permits Division, EPA has elected to develop 34 Categorical Pretreatment Standards. The responsibility for developing these 34 effluent standards rests with the Effluent Guidelines Division of EPA. To date, EPA has promulgated two Categorical Standards, and in addition, 32 sets of standards are under development.

All Federal funding to state and local governments for pretreatment purposes is managed by EPA's Office of Water Program Operations, the Municipal Construction Division administers the dissemination of 201 funds, which are used for matching grants to POTW authorities. Pretreatment program development is one item eligible for funding under this program and may be financed up to 75% through a Section 201 grant. Also within this office is the Water Planning Division, which administers Section 106 funds. These monies are used for matching grants to the states for water pollution control program activities. Pretreatment program development is an eligible cost under the 106 program. The CWA also enables leftover Section 205g monies to be used for state pretreatment program development. Efforts have been made to quantify the amount of Section 106 and 205g funds that have been used for pretreatment, but this information is not available from EPA at this time.

The EPA Regions also offer assistance to states and POTWs for program development. In addition, the Regional Offices review state pretreatment program submissions and make approval recommendations to Headquarters. In non-NPDES states and NPDES states that have not received pretreatment program approval, the Region is responsible for identifying POTWs that need programs, the incorporation of pretreatment program compliance schedules into NPDES permits and the approval of POTW program submissions. In the absence of a local program where one is required, the Region is also responsible for program development and implementation. The region administers funds available to states and municipalities for water programs including pretreatment under Sections 201, 106, and 205g of the CWA and is responsible for enforcement actions against states and POTWs that do not meet their responsibilities under 40 CFR 403.

Federal Pretreatment Program costs are presented in Table A4-I. A man-year of effort for EPA, including fringe and overhead, was estimaed at $39,000. Personnel costs presented in Table A4-I are based on man-years of effort as estimated by each EPA Headquarters Division: Permits, Effluent Guidelines, and Municipal Construction. Regional personnel costs are based on estimates from the Headquarters Permits Division. The contract totals were obtained from the Permits Division based on specific contract awards. The Effluent Guidelines Division estimated the amount of contract money associated with pretreatment as a percentage of their total contract monies. Section 201 grant monies were estimated based on contacts with Headquarters and their respective Regions. In all cases the numbers presented are based on the information available at this time, and should be considered as estimates only.

STATE PROGRAMS

EPA's General Pretreatment Regulations require those states that have been delegated NPDES responsibilities and authority to develop and implement statewide pretreatment programs. Upon approval from EPA, each state assumes responsibility for the following:

- Identification of POTWs that will be required to develop programs.
- Review and approval of POTW program submission.
- Compliance monitoring.
- Enforcement actions.

TABLE A4-I

FEDERAL PRETREATMENT PROGRAM RESOURCE EXPENDITURES *

($ Thousands)

	FISCAL YEAR					
	1977	1978	1979	1980	1981	TOTAL
HQ Permits Division						
Personnel	317	317	200	200	200	1,234
Contracts		100	1,706	1,862	1,419	5,087
HQ Effluent Guidelines Division						
Personnel	273	273	273	273	273	1,365
Contracts	2,340	2,340	2,340	2,340	2,340	11,700
HQ Municipal Construction Division						
Personnel			40	40	40	120
Grants						38,952
Regional Personnel (Including all Pretreatment related personnel)			390	390	390	1,170
						59,628

CONSTRUCTION GRANTS FUNDS OBLIGATED TO POTWs AND STATES FOR PRETREATMENT ($ Thousands)

Region	I	II	III	IV	V	VI	VII	VIII	IX	X	Total for all Regions
Grant Total	2,500	11,221	4,874	1,245	9,240	3,352	2,041	331	2,348	1,800	38,952

Note: These figures have not been adjusted to 1981 dollars. Also included in the personnel figures is a $5,000 per fiscal year total travel cost estimate; no other costs were included.

* Totals for each area are:

Personnel	3,889
Contracts	16,787
Grants	38,952
Total	59,628

Source: Survey of EPA Headquarters and Regional Office Staff

Where there is no POTW program in place, States with approved programs are responsible for compliance monitoring and enforcement actions with respect to the industrial users.

There are currently 32 NPDES states. Of these, the Virgin Islands, although treated like a state, will not be required to develop a pretreatment program and is therefore not included in the summaries presented in this appendix. Currently, eight states have received EPA's approval to implement a statewide pretreatment program. Seven other states have completed all major elements of their program development and are likely to be approved in calendar year 1981. These 15 states with advanced pretreatment programs are identified in Table A4-II.

State pretreatment program status and development costs are presented in Table A4-II. The columns marked "Actual Cost" contain figures obtained from state program development documents or from conversations with state pretreatment personnel. The estimates of development and operational costs were generated using a predictive mathematical equation, which was derived using actual costs. A detailed discussion of this methodology is included as Attachment A4-a. For the purpose of this section development costs were defined as those costs incurred up to the time of official program approval. The estimates of current program development status were obtained in conjunction with the Headquarters Permits Division, which tracks state pretreatment program development. The estimate of development monies spent to date was computed from Permits Division information on state program development status, and the development costs were predicted by the mathematical equation. However, when actual information was available directly from the state, this was used rather than the predicted values.

The estimates show approximately $5.9 million must be spent to develop programs for those states required to do so, and approximately $3.4 million of this projected total has been spent in State program development to date. It should be noted that these figures include Federal grants as well as state monies, as record keeping practices do not allow for a break down to be made. Therefore this figure, when added to the Federal total, exhibits a "double" count of funds.

E A

STATE PRETREATMENT PROGRAMS
($ Thousands)

STATE	ESTIMATED DEVELOPMENT COST	ACTUAL DEVELOPMENT COST	AMOUNT EXPENDED TO DATE ON DEVELOPMENT (Estimate)	PERCENT DEVELOPMENT (Estimate)	ESTIMATED OPERATIONAL Cost ($/year)	ACTUAL OPERATIONAL Cost ($/year)
AL*	112.6	60	60	100	193.5	273.2
CA	649.3		162	25	721	
CO	51.9		0	0	84	
CT*	106.3	270	270	100	158.7	297
DE	23.5		9	40	15.3	
GA*	176.6	263.9	263.9	100	246.0	271.1
HI	7.6		13.5	80	12	
IL	498.3		299	60	539	
IN	278.4		139	50	336.6	
IA*	128	147.7	147.7	100	98	19.7
KA	83.3		25	30	85.5	
MD	83.4		25	30	89.8	
MI	503		500	75	642.0	
MN*	122.6	62.1	62.1	100	312.0	222.3
MS	70		36	90	55	
MO*	176.0	245.7	245.7	100	210	124.2
MT	13.2		0	0	21.7	
NE	44.9		22	50	27	
NV	2.7		2	80	4.5	
NY	464.5		232	50	421	
NC	220.5		110	50	227.9	
ND	2.5		0	0	11.4	
OH	515.7		232	45	625.2	
OR*	77.8	10	10	100	76.4	
PA	430.7		108	25	600	

Note: All costs are in $ Thousands and include Federal contributions

* Approved PT Program.

+ Will soon be NPDES approved.

Source: State program development documents, State Water Pollution Control Agencies, EPA Headquarters.

TABLE A4-II.

STATE PRETREATMENT PROGRAMS (Continued)
($ Thousands)

STATE	ESTIMATED DEVELOPMENT COST	ACTUAL DEVELOPMENT COST	EXPENDED TO DATE ON DEVELOPMENT (ESTIMATE)	PERCENT DEVELOPMENT (ESTIMATE)	EST. OPERATIONAL COST ($/year)	ACTUAL OPERATIONAL COST ($/year)
SC	105.4		90	85	129.9	
TN	153.8		77	50	173.3	
VT	10.7		10	95	36.2	
VI	No program required		--	--		
VA	128		26	20	181.4	
WA	115.4		11	10	106.5	
WI*	208	209.9	209	100	468.9	325.6
WY	2.2		0	0	2.3	
NJ**	267		189	85	304	
PR**	45		27	50	120	
WV**	45.3		27	60	43.4	
TOTAL	5,924.1		3,408.8		7,379.4	

Note: All costs include Federal contributions.

* Approved Pretreatment Program.
** Will soon be NPDES approved.

Source: State program development documents, State Water Pollution Control Agencies, EPA Headquarters

POTW PROGRAMS

EPA's General Pretreatment Regulations require POTWs greater than 5 MGD to have pretreatment programs. EPA or states with approved programs may require POTWs to develop a pretreatment program following an evaluation of the POTW's system, problems, and nondomestic discharges. Where a program is required, it is administered by the POTW authority and is comprised of three general elements. These elements are the legal, procedural, and resource aspects of the program.

For the first element, the POTW authority must document its legal authority to effectively run the program. The procedural aspect of a program involve industrial user identification, compliance monitoring, enforcement actions, reporting, and recordkeeping. The resource analysis must demonstrate the ability of an authority to support its program with the necessary personnel, equipment, financing, and other resources.

Estimate of the status and costs associated with the development of programs by the 2,000 municipalities EPA has identified as requiring programs are presented in Table A4-III. These estimates are derived from a sample survey of 132 POTWs conducted by JRB. This survey represents a statistically valid subset of the total population of POTWs nationaly that will be required to develop pretreatment programs. (Section B-2 describes the survey).

Cost and status data reported by the 132 survey respondents was extrapolated to provide estimates on a national scale. Those sample POTWs reported to be at various stages in the development process (i.e., no action, planning, developing, implementing, and having applied for approval) were assigned a percentage of expenditure to date based on how close they were to having an

TABLE A4-III.

POTW PRETREATMENT PROGRAM STATUS

Design Flow (MGD)	Total No. of POTWs	No. of POTWs No Action	No. of POTWs Planning	No. of POTWs Developing	No. of POTWs Applied for Approval	No. of POTWs Implementing	No Response	Estimated Development Costs to Date ($ millions)
0 ± 5	1,261	714	301	76	38	38	94	5.696
> 5	735	143	245	216	79	33	19	29.204
Total	1,996	857	546	292	117	71	113	34.900
Percentage	100	43	27	15	6	3	6	

Source: Statistical extrapolation of 132 POTW assessment.

approval program. These percentages were chosen based on professional judgement. This schedule was assigned as follows:

Status	% Expended to Date
No action	0
Planning	20
Developing	60
Implementing	90
Applied for Approval	100

By matching these percentages to development cost figures derived in Appendix C3.2.5 for each of the sample POTWs, an estimate of dollars spent on development to date was obtained. These figures were then simply scaled up to the 2,000 POTWs to yield the total cost expended to date to develop local pretreatment programs. It should be noted that this estimate includes Federal monies also. The results are illustrated in Table A4-III. From the information in the table the following conclusions can be drawn:

- 79% of POTWs greater than 5 MGD have made some programs toward obtaining an approved pretreatment program.
- 45% of the POTWs less than 5 MGD have made some progress toward obtaining an approved pretreatment program.
- 15% of POTWs greater than 5 MGD have applied for approval of or are actually implementing pretreatment programs.
- 6% of POTWs less than 5 MGD have applied for approval of or are actually implementing pretreatment programs.

These results imply that the size classification imposed by the Federal Pretreatment Regulations has had a noticeable effect. EPA's decision to make a pretreatment program mandatory for POTWs with flow greater than 5 MGD has resulted in more progress for this group of POTWs. It should be noted that larger POTWs are also more likely to have the fiscal and technical resources to more readily develop and implement a pretreatment program.

The figures in Table A4-III represent monie spent by POTWs to comply with Federal Pretreatment Regulations since their promulgation in June 1978. They aer based on the current status of local programs. For those programs that are only partially developed a portion of the cost for full program development is shown. It should also be noted that these expenditures include monies obtained through Federal grants as well as local funding.

Table A4-III does not include operational cost information. Detailed information on operational costs for pretreatment programs on the local level is sparse, primarily because of the lack of operating programs. Efforts were made through the EPA Regions to obtain more data, but not enough information was obtained to estimate current or projected operational costs for local programs in this baseline report. POTW operational costs are addressed in Appendix C.

SUMMARY

Compiling the available data for this appendix was complicated by two factors: (1) the data had to be obtained from numerous government agencies who do not keep consistent data records, and (2) in many instances, pretreatment information and costs are not tracked as separate line items. Therefore, extrapolations from existing data and calculated estimates had to be used to complete the necessary data base. A detailed description of the estimating methodology for state program costs appears in the attachment to this appendix while the methodology for local program cost estimates appear in appendix C.3.2.E of this report. It should be noted that because estimates were used, the data are much more reliable when viewed on a national scale than when analyzed on a smaller categorical scale.

Federal

Close to $60 million has been spent at the Federal level for the development and implementation of the Pretreatment Program since FY 1977. This includes personnel, contracts, and grants.

ATTACHMENT A4-a

STATE PRETREATMENT PROGRAM COST

The purpose of this section is to derive individual state pretreatment program cost estimate which can be totalled to yield an estimate of the total cost of pretreatment at the state level. For the purpose of this analysis, this total has been limited to the 35 states that have alrady received or will soon receive NPDES program delegation. These 35 states are those required by EPA to have pretreatment programs in the immediate or near future.

Methodology

Regresssion analysis is one tool that can be used to estimate the costs of developing and implementing a state pretreament program. In this type of analysis, a statistical relationship between a dependent or cost variable and some number of explanatory variables is derived in the form of an equation for predicting a state's program cost. This equation is represented by the following general form:

$$y = a + b_1 x_1 + b_2 x_2 + e$$

where:

y = the cost to develop and implement a state pretreatment program

x_1, x_2 = explanatory variables testsd (i.e., population, total flow, value of shipments, and number of POTW s)

b_1, b_2 = coefficients to be estimated

a = constant term

e = error term

Using the cost data available, this equation can generate an estimate for the cost of pretreatment to states for which no cost figures are currently available.

Data Collection and Limitations

The basic source of data used in this analysis are:

- State pretreatment program submittals
- Phone contacts with State Pretreatment Coordinators
- Statistical Abstract of the United States 1980 (U.S. Bureau of Census 1980)
- NEEDS Survey containing information on flow and the number of POTW (U.S. EPA 1980).
- 1977 Census of Manufacturers (U.S. Bureau of Census 1977).

Separate regression analyses are performed for the development and implementation costs of state pretreatment programs. (Of the 15 states with advanced programs, Vermont and connecticut were excluded from this statistical analysis because their state agencies will directly administer all state pretreatment activities. Since no local POTW programs will be developed in these states, they are considered atypical). The development cost analysis is based on observations of 13 states. Of these 13 states, 8 have received EPA approval while the other 5 are in the final stages of the review process. The development cost figures for the 8 approved states were obtained from their pretreatment program submittals, and the remainder were compiled from phone contacts with state pretreatment coordinators.

For the implementation cost analysis, 12 individual state pretreatment programs were reviewed. Of these 12 programs, 8 have received EPA approval, while the remainder are currently awaiting approval. The 12 operating cost figures were extracted from program submittals. Since most of these programs provided only mn-year estimates over a 5-year period, they were converted into dollar amounts by multiplying by $27,000. This number was used to represent an average, fully loaded salary for a state employee involved in pretreatment. The 5-year cost projections were then evaluated statistically (i.e., mean, median) to arrive at a single estimate of the state's annual pretreatment cost.

Data on the explanatory variables used in both analyses were derived from three sources. Value of shipments was obtained from the 1977 Census of Manufacturers; number of POTWs requiring pretreatment, actual flow, and total number of POTWs were obtained from the NEEDS Survey; and population was obtained from the U.S. Bureauof Census (1980).

Results

Several regression analyses were performed to test the strength of the relationship between the dependent or cost variable and alternative explanatory variables. The results of these analyses of state implementation and development costs are presented in Tables a-1 and a-2.

Based on these results, equation 8 in Table a-1 was selected as a predictor of the state's implementation cost. The rationale behind this selection is straightforward from both statistical and common sense perspectives. Statistically, equation 8 is the best predictor because it accounts for the greatest fluctuation in the dependent variable ($R^2 = .93$). From a common sense standpoint, the explanatory variables in equation 8 are key state pretreatment cost determinants. Value of shipments provides a measure of industrial activity within the state, and the number of POTWs within the state requiring pretratment is a good indication of the amount of supervision required at the state level. Both of these variables prove to be statistically significant in equation 8.

Equation 5 in Table a-2 was selected to predict the cost incurred to develop a pretreatment program at the state level. This selection is based on the strength of the coefficient of determination ($R^2 = .90$). This coefficient shows that 90% of the observed fluctuation in development cost can be explained by equation 5. The same explanatory variables are used as in the implementation cost analysis but only the value of shipments is statistically significant.

Table a-1
State Implementation Cost Regression Equations

Equation Number	Dependent Variable	Functional Form	Value of Shipments $ Million	Requiring Pretreatment	Actual Flow (MGD)	Population sands)	Total of POTSs	Constant	Degrees of Freedom	Coefficient of Determination R^2	Standard Error
1	State Cost	linear		1.369 (2.20)	1.843 (.25)			58.72 (.48)	11	.35	186.2
2	State Cost	log		1.279 (703)	.247 (1.29)			-.574 (-.64)	11	.84	.60
3	State Cost	linear		2.358 (2.31)				77.37 (.84)	11	.35	177.2
4	State Cost	log		1.283 (6.69)				.089 (.12)	11	.82	.62
5	State Cost	linear	7.715 (6.58)					21.19 (.47)	11	.81	95.1
6	State Cost	log	.885 (768)					2.462 (6.68)	11	.86	.55
7	State Cost	Linear	7.133 (4.9)	.483 (.71)				2.487 (.05)	11	.82	97.52
8	State Cost	log	.535 (3.58)	.615 (2.89)				1.014 (1.77)	11	.93	.42
9	State Cost	linear				.078 (7.16)		-79.9 (-1.50)	11	.83	88.6
10	State Cost	log				1.377 (5.64)		-6.16 (-3.09)	11	.76	.71
11	State Cost	linear		.472 (.75)		.072 (5.41)		-91.4 (-1.62)			
12	State Cost	log		.78 (4.54)		.737 (3.69		-4.10 (-3.3)	11	.92	.41
13	State Cost	linear				.078 (6.84)	1.29 (.34)	-92.4 (-1.39)	11	.83	92.8
14	State Cost	log				1.60 (8.59	-.56 (-3.29)	-6.93 (-4.82)	11	.89	.50

TABLE a-2

STATE DEVELOPMENT COST REGRESSION EQUATIONS

Equation Number	Dependent Variable	Functional Form	Value of Shipments ($ million)	No. of Requiring Pretreatment	Constant	Degrees of Freedom	Coefficient of Determination R^2	Standard Error
1	State Cost	linear		1.96 (3.53)	40.8 (1.00)	12	.53	101.3
2	State Cost	log		.827 (4.40)	1.57 (2.32)	12	.64	.80
3	State Cost	linear	5.42 (9.67)		-2.88 (-0.14)	12	.89	47.9
4	State Cost	log	.732 (4.45)		2.37 (4.69)	12	.64	.79
5	State Cost	linear	5.32 (5.89)	.058 (.14)	-3.41 (-0.16)	12	.90	50.3
6	State Cost	log	.403 (1.23)	.428 (1.15)	1.81 (2.62)	12	.68	.78

By entering data on the explanatory variables for each state into equation 8 for implementation and equation 5 for development, an estimate of the cost of each state's pretreatment program can be derived. For the purposes of the baseline analysis, the estimates for each of the 35 NPDES states were summed to yield an estimate of the total cost of pretreatment at the state level. The estimated operating cost for these 35 states is $7.4 million, and the estimated development cost is $5.9 million.

A-5. SUMMARY ASSESSMENT OF STATE ENVIRONMENTAL REGULATIONS AFFECTING INDUSRIAL WASTE CONTROL AT POTWS

Several regulatory options being considered in this analysis of the National Pretreatment Program would result in state assumption of greater responsibility for standard setting for administration and oversight of industrial waste control programs at POTWs. The following cursory assessment of state environmental regulations was performed to measure how far along states are in acquiring the basic environmental regulatory tools which would enable them to control industrial (and particularly toxic) waste impacts at POTWs. The extent to which state environmental programs and regulations are lacking or present may have implications on the feasibility and effectiveness of state primacy in controlling industry-related problems at POTWs. Moreover, the availability of existing state controls will determine the magnitude of the state's administrative burden in implementing pretreatment programs for each of the options. For instance, option 4 of the analysis of pretreatment options (water quality standards for POTWs) calls on pretreatment programs to be instituted at POTWs exceeding toxic water quality standards. In states where these standards have not been promulgatd, a substantial administrative burden and program delay may be encountered.

This assessment focuses on state legislation, rules, and programs for water protection, hazardous and solid waste management, and air pollution control. The existence of environmental programs, and, where applicable, the date of authority delegation, are given. To highlight those concerns most relevant to pretreatment, key regulations were examined. These included water quality standards for toxic organics and heavy metals, solid waste regulations affecting municipal sludge disposal options, and air rules affecting incineration.

Table A5-I presents the findings of this assessment. A measure of relative industrialization and value of manufacturing shipments is included to allow a quick correlation between the magnitude of possible industrial waste problems in a state and the extent of environmental regulation within that state.

TABLE A5-1

		WATER PROTECTION					SOLID WASTE MANAGEMENT							AIR PROTECTION	
TATE	Manufacturers Shipments ($ Million)	NPDES Program	Pretreatment Program	Water Standards	Toxic Organics	Metals	SW Rules	HW Rules	Landfill Guidance	Impoundment Guidance	Incineration Guidance	Landspread Food Crops	Other Utilization	APC Laws	Incineration Controls
Alabama	21	'79	'81	'77+			'72	'80	x		x			'71	x
Alaska	1			73			72	x	x		x	x**		71	x
Arizona	7			68	x	x	76		x		x	x	x	62	x
Arkansas	12			75			73	80	x		x	x		65	x
California	121	73		68	x	x	?	74	x			x		?	
Colorado	10	75		74	x	x	72		x	x		x*		73	x
Connecticut	20	73	81	77			75	x	x					71	x
Delaware	3	74		75	x	x	74	x	x			x*	x	73	x
Florida	22			74	x	x	74	x	x			x*	x	71	x
Georgia	33	74	81	74			72	80	x		x	x		78	x
Hawaii	2	74		73			74	x	x		x	x		72	x
Idaho	4			73	x	x	73	x	x		x	x	x	72	x
Illinois	93	77		72	x	x	73	x	x			x*	x	70	x
Indiana	52	75		77+	x	x	74	x	x		x	x*		61	x
Iowa	24	78	81	77+	x	x	71	x	x		x	x*	x	77	x
Kansas	16	74		74			72	x	x		x	x	x	67	x
Kentucky	23			71	x	x	75	80	x		x		x	68	x
Louisiana	30			77			68	79	x		x		x	79	x
Maine	5			77		x	74	(*)	x	x	x	x*	x	69	x
Maryland	16	74		73			--	80	x			x*	x	79	
Massachusetts	31			67			71	73	x			x		67	x
Michigan	94	73		73			54	x	x			x*	x	65	x
Minnesota	22	74	81	64	x	x	70		x		x	x*	x	67	
Mississippi	13	74	81#	74+	x	x	78	80	x		x	x*		42	
Missouri	33		81	73	x	x	73	78	x		x	x*	x	65	x

TABLE A5-I (Continued)

STATE	Manufacturers Shipments ($ Million)	WATER PROTECTION					SOLID WASTE MANAGEMENT							AIR PROTECTION	
		NPDES Program	Pretreatment Program	Water Standards	Toxic Organics	Metals	SW Rules	HW Rules	Landfill Guidance	Impoundment Guidance	Incineration Guidance	Landspread Food Crops	Other Utilization	AFC Laws	Incineration Controls
Montana	3	74		73		x	72	x	x		x			67	x
Nebraska	9	74		76			75	x	x		x	x		71	x
Nevada	0.9	75	81#	67+	x	x	77	x	x		x			71	x
New Hampshire	4			73			(*)		x			x**		70	x
New Jersey	50			64	x	x	74	x	x		x	x*	x		
New Mexico	2			73			74	(*)	x			x		67	
New York	87	75	81#	66	x	x	77	x	x	x	x	x	x	72	x
North Carolina	41	75		74	x	x	79	x	x		x			51	x
North Dakota	1	75		73	x	x	76	x	x		x			69	x
Ohio	96	74		75	x	x	76	80	x	x	x	x*	x	67	x
Oklahoma	13			73+	x	x	71	79	x			x		67	x
Oregon	13	73	81	73+	x	x	72	76	x	x	x	x*	x	69	x
Pennsylvania	80	78		67	x	x	71	x	x		x	x*	x	60	x
Rhode Island	5			77			75	79	x		x			66	x
South Carolina	20	75	81#	72			71	72	x		x	x*		71	x
South Dakota	2			77	x	x	73	x	x		x			67	x
Tennessee	29	77		73	x	x	75	x	x		x		x	67	x
Texas	93			75			75	79	x		x	x	x	67	x
Utah	5			65	x	x	74	80	x			x		67	x
Vermont	2	74	81#	67	x		78		x			x*		68	x
Virginia	24	75		70	x	x	71	x	x	x	x	x	x	70	x
Washington	22	73		73			(*)		x	x		x	x	67	x
West Virginia	9			74	x	x	74	x	x			x		?	x
Wisconsin	39	74	81	73			73	x	x		x	x*		67	x
Wyoming	1	75		73	x		75	x	x					73	

EXPLANATION OF CATEGORIES AND NOTES FOR TABLE A5-I

Manufacturers Shipments –	Total value of manufacturers' shipments in 1977, SIC codes 20-39 excluding 23 are represented in the survey (Source: Annual Survey of Manufacturers, Dept. of Commerce, 1977)
NPDES Program –	Date of EPA Program approval (Source: BNA, Environmental Reporter)
Pretreatment –	Date of EPA approval of Industrial Pretreatment Program # = pending HQ review (Source: EPA memo)
Water Standards –	Initial date of state adoption of Federally approved standards of water quality (Source: BNA, Environmental Reporter)
Toxic Organics/Metals –	Standards include numerical criteria for toxic substances organics or metals (Source: EPA survey)
Solid Waste Rules Hazardous Waste Rules }	Date of initial adoption of rules by the states (*) indicates that legislation has been enacted but rules have not been adopted x in the HW column indicates that SW rules also cover HW Source: BNA, Environmental Reporter)
Landfill Impoundment Incineration Landspreading Other }	Guidance for disposal options is included in the SW and HW rules * criteria for Cd, Pb and/or PCBs are specified ** disposal option is prohibited "other" includes utilization for non-food chain landspreading, composting, fuel utilization, marketing as fertilizer (Source: EPA, Sludge Management: A Comparison Between State and Proposed Federal Guidelines, 1979)

The following general trends and characteristics were observed:

- Water Protection Requirements and Guidance

  - NPDES Programs:

    Thirty-three states now have established EPA-approved programs. The earliest approvals were obtained by California, Connecticut, Michigan, Oregon and Washington in 1973. Most of the NPDES states' programs were obtained in 1975.

  - State Industrial Pretreatment Programs:

    Programs in eight states (Alabama, Connecticut, Georgia, Iowa, Minnesota, Missouri, Oregon and Wisconsin) have been approved. Programs for four states are currently being reviewed by EPA Headquarters.

  - Water Standards:

    Federally-approved water standards were adopted by ten states prior to 1970. Nine of those ten states have also established contamination criteria for toxic organics and metals. To date, 30 states have established criteria for organics; twenty-nine have criteria for metals. Coverage does vary significantly among the states. For example, Maine rules specify acceptable levels for chromium while Colorado rules cover total metals, CN, PCBs, and 17 pesticides.

- Solid Waste Management Requirements

  - Solid Wastes:

    Prior to 1976, 38 states had adopted rules governing the disposal of solid wastes. By 1979, the remaining states had followed suit. State rules in general treat landfill disposal of wastes. Sixty to 70 percent of the states also offer guidance for landspreading and incineration methods. Less than half of the states have adopted rules to specifically address "other" options such as fuel utilization or marketed fertilizer products. Many states do include, however, provisions for operation of "experimental" facilities on a case-by-case basis.

  - Hazardous Wastes:

    Over 80 percent of the states have amended solid waste rules or adopted a separate body of rules to specifically treat hazardous wastes. However, state rules for hazardous waste management vary dramatically. For example, Virginia has established a single rule: "Hazardous wastes will be disposed of in a manner approved of by the Health Commissioner." In contrast, the Utah rules consist of nearly 100 pages of regulations derived largely from the EPA rules.

- Air Pollution Controls

  Over 50% of the states had enacted legislation to protect air quality prior to 1970. The remaining states have since adopted laws for air. Nearly 90% of the states have specifically addressed incineration as a potential source of pollutants, although the extent of control varies from state to state.

As evidenced above, there is substantial variation in the coverage and vigorousness of the state regulations governing water and air protection and solid waste management. Given this inherent tendency toward diversity, it is probable that, without a uniform National Pretreatment Program, State efforts to regulate industrial wastes at POTWs would vary considerably. Moreover, the above assessment shows that several states were motivated to take regulatory action to comply with federal environmental laws. Although some states had other motivations, it is conceivable that, in the absence of a mandatory National Pretreatment Program, fewer states would take steps to control industrial waste problems at POTWs.

APPENDIX B

DOCUMENTATION OF PROBLEMS AT POTWS

INTRODUCTION

Appendix B provides documentation and review of technical problems at POTWs. The objective of this search and in-depth analysis of the literature and unpublished sources is to review POTW operational and maintenance data, effluent quality, worker health and safety, and pretreatment program motivation. The pretreatment regulations were initially developed to prevent upset problems caused by industrial waste at POTWs. This appendix is directed toward specfic POTW problems not treated subsequently in the POTW computer model. The case study analyses and results from Appendix B also provide information and a basis for assumptions from which the POTW computer model has been developed; see Appendix C.

Appendix B is divided into the following seven sections:

- B-1, Operation and Maintenance Data Base
- B-2, 132 POTW Local IU Control Assessment
- B-3, 77 POTW Visits
- B-4, 40 POTW Study
- B-5, Case Studies
- B-6, Worker Health and Safety, Air, and Groundwater
- B-7, Summary.

The O&M data file (Section B-1) was developed by the Municipal Construction Division of The Environmental Protection Agency (EPA) and includes the investigation and findings of approximately 1,500 POTW site inspections made annually by EPA and state personnel. The results of their investigations are entered in a standard formatted computer file. This data file covers a multitude of O&M problems that are readily quantifiable.

The Assessment of 132 Local Industrial Wastewater Control Programs (Section B-2) was a study conducted by JRB Associates, focussing on the administrative issues surrounding the Pretreatment Program. Estimates of pretreatment in place, program motivation, monitoring and enforcement, National Pollutant Discharge Elimination System (NPDES) violations, and other administrative functions can be made from this study.

JRB has made site visits to 77 small (< 5 MGD) POTWs (Section B-3) to assess their needs and compliance with the Preteatment Program. This data source provides a firsthand report of the problems POTWs experience as a result of industrial discharges. Section B-3 addresses specific industrial discharge problems such as reported NPDES violations and sludge contamination.

The 40 POTW Study, (Section B-4) was an in-depth look at POTW toxicity levels and included continuous monitoring of the plant influent, effluent, and sludge. This is one of the few studies that has detailed analytical data on priority pollutants in POTW wastewater streams. The 40 POTW Study also provides a useful comparison to the 77 POTW Study because the 40 POTW Study includes only plants that had a total flow
> 5 MGD.

Numerous published articles exist on case studies of POTWs with Pretreatment Programs (Section B-5). These case studies provide data on POTW operation before and after implementation of a Pretreatment Program. Furthermore, some of these studies report the difference in influent and effluent quality before and after pretreatment and discuss the benefits derived from the program.

The potential environmental problems associated with industrial effluent treatment are numerous. They include worker health and safety, air pollution, and groundwater contamination. Section B-6 discusses these problems and reports incidences where industrial effluent has caused environmental problems.

Section B-7 is a generic summary of POTW operational problems.

APPENDIX B-1

OPERATION AND MAINTENANCE DATA BASE SUMMARY

Publicly owned treatment works (POTWs) are inspected annually to determine compliance with National Pollutant Discharge Elimination System (NPDES) permits and to develop an operation and maintenance (O&M) data base (Derieux 1980). The 1980 O&M data base includes information from 1,547 POTWs located in 24 states with 78% treating less than 5 MGD.

The analysis of the O&M data base compares several key variables for POTWs that receive industrial waste to POTWs that receive no industrial waste. Information is not available in the database regarding POTWs that have or have not instituted pretreatment. Approximately 21% of the POTWs report that they receive some quantity of industrial waste. In reality, the percentage may be much higher. Of the POTWs that report O&M problems associated with industrial waste, 31% do not report the quantity of industrial flow into their facilities; a possible explanaion is that these POTWs have not conducted an industrial waste survey.

POTWs that receive industrial waste cite O&M problems associated with that waste as the most frequent O&M problem (30% of all O&M problems). Of these POTWs, 42% also report a problem with organic overloads, while 28% of all POTWs in the data base report an organic overload problem.

The percentage of POTWs having secondary treatment reporting major or minor O&M problem associated with industrial wastes generally increases with the average daily flow up to 100 MGD. In the range of 5 to 100 MGD 48 to 68% of the POTW report major and minor O&M problems associated with industrial waste.

An indicator of the significance of this problem is the violation of NPDES permit requirements. More than 60% of the POTWs reporting O&M problems associated wih industrial waste violate at least one of their permit requirements. The percentage violations by POWs increases only slightly with the percentage industrial flow.

Sewage bypasses occur when untreated or incompletely treated waste loads are discharged to receiving waters. Of the POTWs receiving industrial waste, about 35% report monthly sewage bypasses. On the average, these bypass events occur 3 times per month, each lasting close to 6 hours in duration. The percentage of POTWs reporting bypasses is highest in the industrialized North Central and Northeastern United States.

O&M DATA BASE

The O&M data base is compiled form reports of POTW inspections conducted by EPA and the States. The purpose of these inspections is to ensure compliance with the requirements of NPDES permits and of construction grants, and to assess personnel and equipment performance. These inspections are required by Section 210 of the Clean Water Act and the results are summarized and reported to Congress annuually. Inspection frequency is determined by the requirements of the State and the degree and type of problems encountered at each facility. Some facilities are monitored more than once a year, while others are monitored less frequently.

The data elements addressed by the inspections and contained in the O&M data base are shown in Table B1-I. Four generic categories of data are represented:

- Identification information
- Facility datta
- Pollution load data
- Facility assessments.

Identification Information

Identification data include name, location of plant, the State permit number, the type of receiving body, and the owner of the facility.

TABLE B1-I.

Data Elements Contained in the Operation and Maintenance Data Base

Identification Section

- Facility Name
- Address
- State Permit Number
- Owner of Facility
- Type of Receiving Body

Facility Data

- Type of Sewer System (Combined/Separate)
- Year Plant in Operation
- State Effluent Standards
- Ambient Water Quality Standards or Uses of Receiving Body
- Frequency of Bypassing Wastestream
- Reason for Bypassing
- Is Bypassed Stream Chlorinated? (Chlorination)
- Occurrence of Sewer Overflows in Plant or Upstream
- Reports of Groundwater Contamination
- Infiltration Problems
- Main Difficulty Experienced with Industrial Wastes
- Type of Effluent Release Seasonal, Continuous, Intermittent
- Description of Major Plant Problems
- Schematic of Plant

Pollution Load Data

- Average design flow (mgd)
- Average daily flow rate (mgd)
- Peak flow, dry and wet weather (mgd)
- Annual average BOD_5 load in influent
- Annual average SS load in influent
- Principal types of industrial wastes discharges to system
- Population equivalent (BOD) of industrial wastes
- Population equivalent (SS) of industrial wastes
- Volume of industrial wastes
- Design, actual NPDES requirements for flow (are monthly, and peak flow, (mgd), and are monthly influent and effluent, SS (mg/l), BOD_5 (mg/l), DO (mg/l) residual chlorine (mg/l), coliform (total and fecal per 100 ml) total phosphorus (mg/l), total nitrogen (mg/l); and maximum and minimum pH range.
- Percent removal of each recorded pollutant
- Frequency of analysis for each pollutant
  - influent
  - points along treatment system
  - receiving stream
- Indication of whether plant meets NPDES permit requirements and achieves design efficiency

Facility Assessment Information

- Assessment of plant maintenance operations
  - alarms
  - power sources
  - operator training
  - budget
  - parts inventory
- Personnel data - number, man hours
- Assessment of the operation of each waste treatment component

Facility Data

Facility data include descriptive information on the POTW:

- Type of sewer system
- Year in which the POTW became operational
- Problems associated witth infiltration, overflow, and industrial discharges
- State water quality standards for receiving waters
- State effluent standards
- Schematic of the POTW showing each treatment process component.

Pollution Load Data

Pollution load data include total and industrial flow rates, influent and effluent BOD and TSS loading, NPDES permit requirements, pollution reduction efficiency, and frequency of sampling and analysis.

Plant Assessments

Data in this category include an overall facility rating; individual ratings of equipment and waste treatment component operation; a compilation of personnel classification, certification, and training data; and specific problems or deficiencies associated with POTW operations.

CHARACTERISTICS OF POTWS INCLUDED IN THE O&M DATA BASE

The sample size for 1980 in he O&M data base includes 1,547 POTWs distributed across 24 States. The sample included states from 7 of the 10 EPA regions; region III (Maryland, Pennsylvania, Virginia, and West Virginia), region VII (Iowa, Kansas, Missouri, and Nebraska), and region IX (Arizona, California, and Nevada) are not included in the data base. More than 97% of thes POTWs provide secondary treatment, and 78% receive an average daily flow of less than 5 MGD. Figure B1-1 provides the distribution of POTWs in the O&M

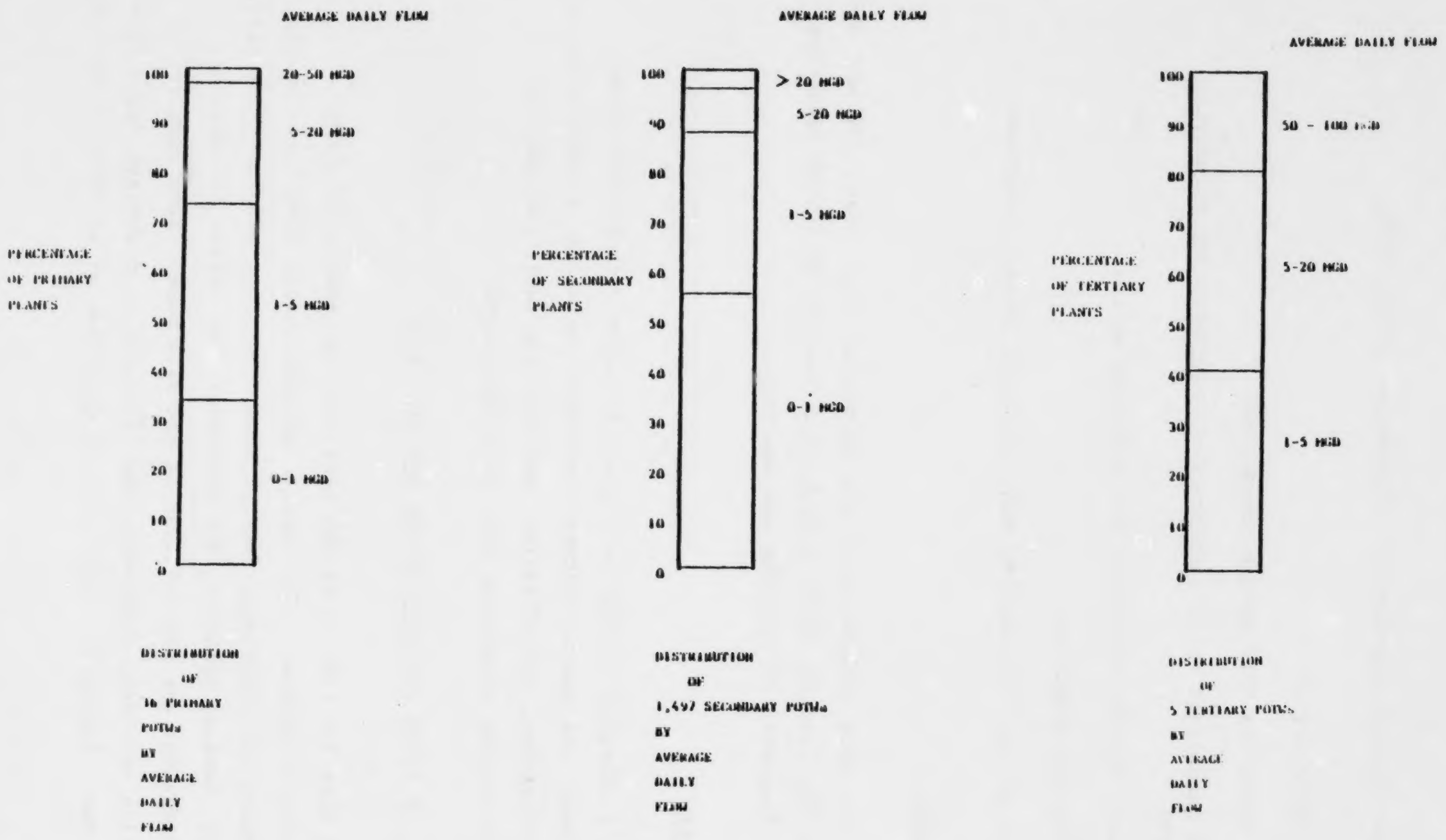


FIGURE B1-1. Distribution Of POTWs In The O&M Data Base By Level Of Treatment And Average Daily Flow

data base, presented by level of treatment and average daily flow. The total daily flow of the POTWs in the O&M data base is 10,970 MGD; the mean flow for these POTWs is 7.1 MGD, however this figure is positively skewed by several extremely large POTWs.

At least 21 percent of the POTWs in the O&M data base receive some quantity of industrial waste; the actual number is probably much higher. Due to incomplete responses of the survey questions, the precise number of POTWs that actually receive industrial waste cannot be determined. More than 70 percent of the POTWs that report receiving industrial waste provide secondary treatment and have an average daily flow less than 5 MGD. The total volume of industrial wastes received by POTWs included in the O&M data base is 6,061 MGD; the mean volume is 3.9 MGD.

SUMMARIES OF CONCLUSIONS AND FINDINGS FROM THE O&M DATA BASE

The conclusions that can be drawn from the O&M data base are explained in the following sections and are summarized below:

- The percentage of POTWs reporting occurrences of sewage bypasses is highest in the industrialized North Central and Northeastern United Sates.
- Of the 330 POTWs that report receiving industrial waste, about 35 percent report monthly sewage bypasses.
- Of the 139 POTWs that were evaluated for the operation of their sludge disposal processes, not one received a totally satisfactory rating.
- Of the 330 POTWs which receive industrial waste, 42 percent report a problem with organic overloads; of all the POTWs in the data base, 28 percent report a similar problem.
- Other than plant obsolescence, major O&M problems associated with industrial waste and with sludge handling and processing rank highest for all POTWs. Plant obsolescence was reported as a major problem by 355 plants; industrial waste, and sludge handling and processing, were reported as major problems by 195 plants and 194 plants, respectively. Of the plants that receive industrial waste, O&M problems associated with that waste rank highest.
- Of the 476 POTWs that report O&M problems associated with industrial waste, 79 percent receive less than 5 MGD average daily flow.

- Of the 330 POTWs that report receiving industrial waste, 72% report an O&M problem associated with the waste.
- The percentage of POTWs having secondary treatment reporting major or minor O&M problems associated with industrial wastes generally increases with the average daily flow up to 100 MGD. In the range of 5 to 100 MGD 48 to 68% of the POTW report major and minor O&M problems associated with industrial waste
- More than 60% of the POTWs that report an O&M problem associated with industrial waste are in violation of at least one of their NPDES permit requirements.

Bypass Data

The O&M data base includes information on the monthly occurrence of sewage bypasses at POTWs. Of all the reported sewage bypasses, 79% occur in POTWs that receive less than 5 MGD average daily flow. While POTWs of this size account for most of the monthly bypasses, larger POTWs also report the occurrence of bypass events. Figure B1-2 presents the percentage of POTWs within average daily flow categories that report monthly sewage bypasses. The figure indicates, for example, that about 35% of all of the secondary treatment POTWs that receive 1-5 MGD average daily flow report monthly sewage bypasses, and that about 89% of all the secondary treatment POTWs that receive 100-200 MGD report monthly sewage bypasses.

Bypass durations reported by POTWs and contained in the O&M data base range from 1 hour per month to more than 24 hours per month. Of the 227 POTWs that reported the duration of monthly sewage bypasses, 59% stated that the average bypass lasts less than 10 hours, and 12% reported that the average bypass lasts more than 24 hours. The mean duration of sewage bypasses is 5.9 hours; the mean frequency is about 3 occurrences per month.

The percentage of POTWs reporting instances of bypasses is highest in the North Central and Northeastern United States; these geographic areas correspond to EPA Regions II and V. Industrialization is very high in these regions. Figure B1-3 provides the percentage of POTWs within EPA's 10 regions that report monthly sewage bypasses. Of the POTWs in EPA regions II and V, 47% and 55%, respectively, report monthly bypasses.

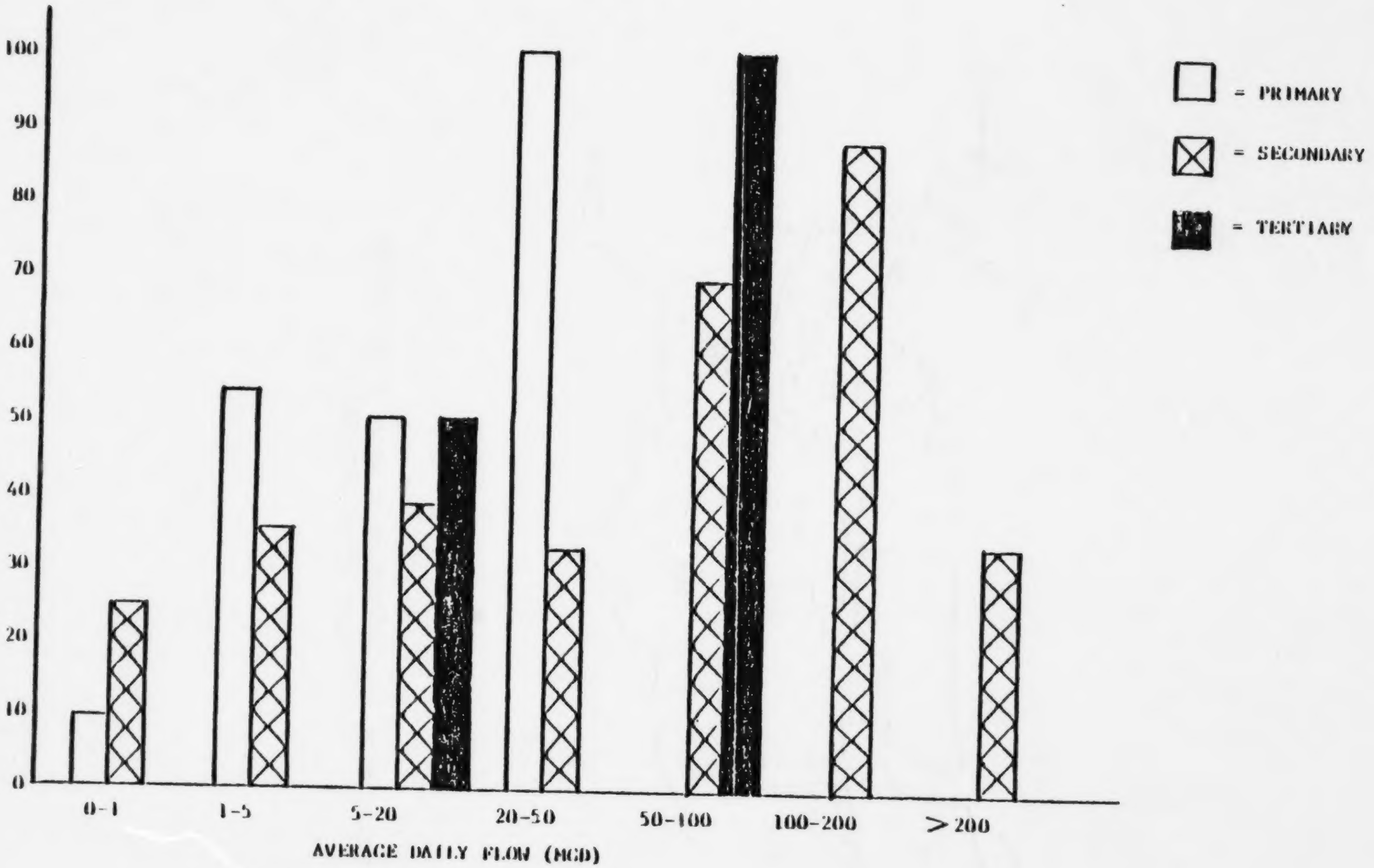


FIGURE B1-2. PERCENTAGE OF POTWs REPORTING MONTHLY SEWAGE BYPASSES BY AVERAGE DAILY FLOW CATEGORIES

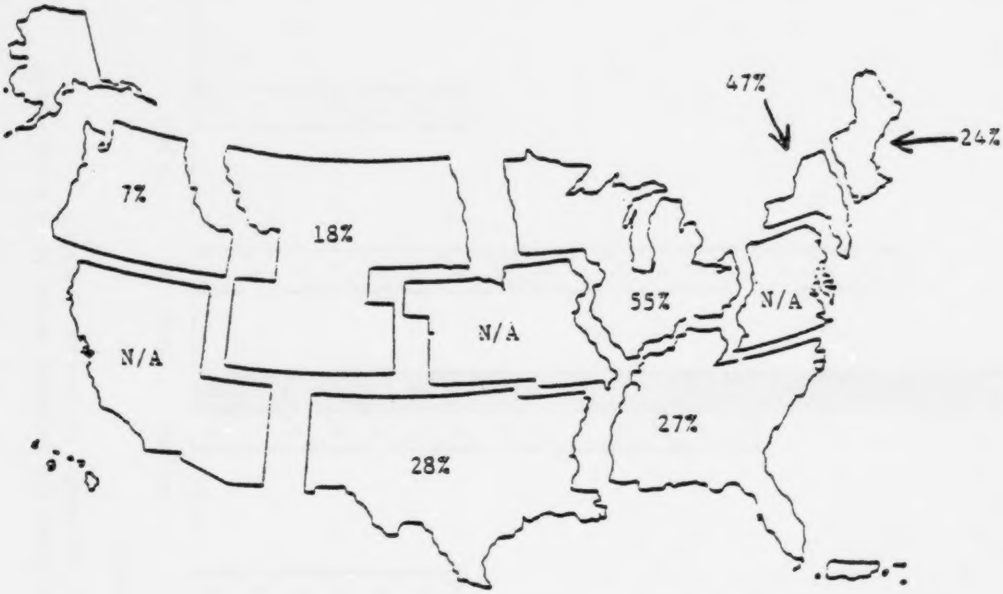

47%
24%
7%
18%
55%
N/A
N/A
N/A
27%
28%

FIGURE B1-3. PERCENTAGE OF POTWs BY EPA REGION WHICH REPORT BYPASSES.

Of the POTWs that report monthly bypasses, 18% discharge into water classified for body contact (swimming, etc.); 44% discharge into waters classified for all uses except body contact, 33% discharge into waters classified for special use by the State; and 5% report no data on receiving waters. The O&M data base does not contain a subcategory for drinking water usage.

Figure B1-4 provides information on monthly sewage bypasses for POTWs that report industrial waste as an influent to the plant. Of these POTWs, about 35% report monthly bypasses.

Sludge Disposal

The O&M data base includes information on how sludge is disposed of by the POTWs. Figure B1-5 shows the percentage distribution of sludge disposal techniques for the POTWs that reported this information. Sanitary landfill and agricultural fertilizer appear to be the most common disposal techniques. The third most common technique, long distance transport, is not really an end disposal in itself. Presumably, a high percentage of the sludge reportedly disposed of in this manner is actually landfilled or land spread.

Of the 139 POTWs evaluated for operational effectiveness of the sludge dissposal processes, not one POTW was given a totally satisfactory rating. All of these POTWs provide secondary treatment. Approximately 67% of these POTWs were given a marginal ratingg for the operartion of sludge disposal processes, and an additional 31% were given an unsatisfactory rating. More than 70% of all of the marginal ratings were given to POTWs receiving less than 5 MGD average daily flow.

Overloads

Overloads, whether hydraulic or organic, create an O&M problem for POTWs. The O&M data base includes information on the relative length of overloads (continuous or periodic), the type of overloads, and the causes of overloads. Table B1-II provides information on the types of overloads at POTWs, and whether they are considered to have a major or minor effect on plant performance. Of all the POTWs in the O&M data base, 74% have a problem associated

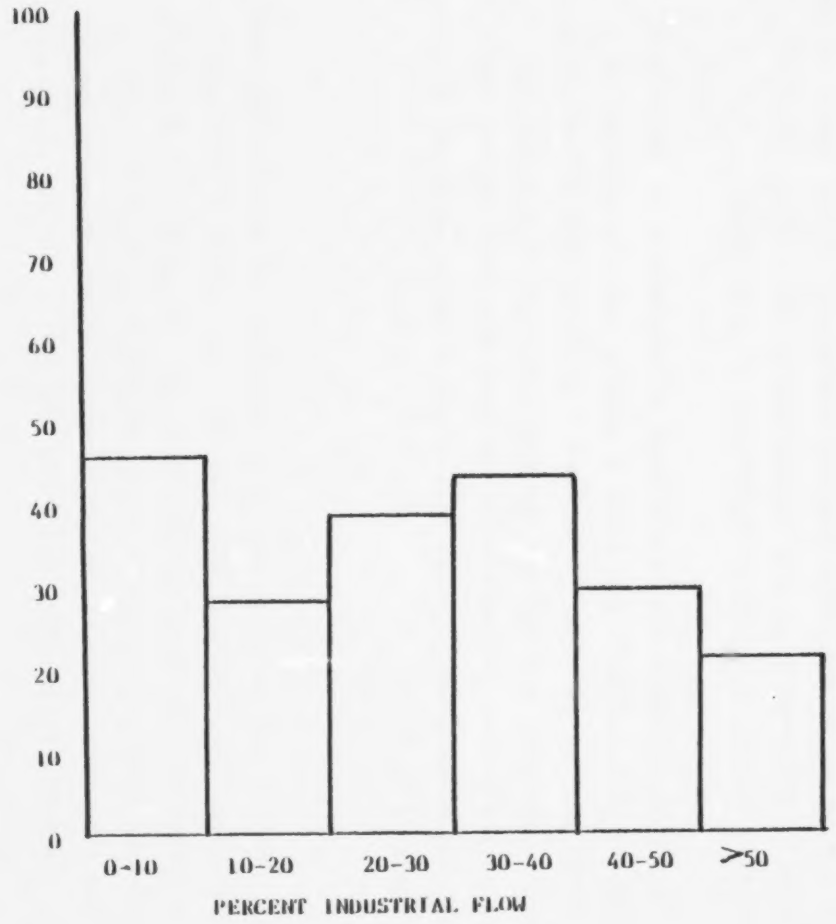


FIGURE B1-4. PERCENTAGE OF POTWs BY INDUSTRIAL FLOW CATEGORIES REPORTING MONTHLY SEWAGE BYPASSES

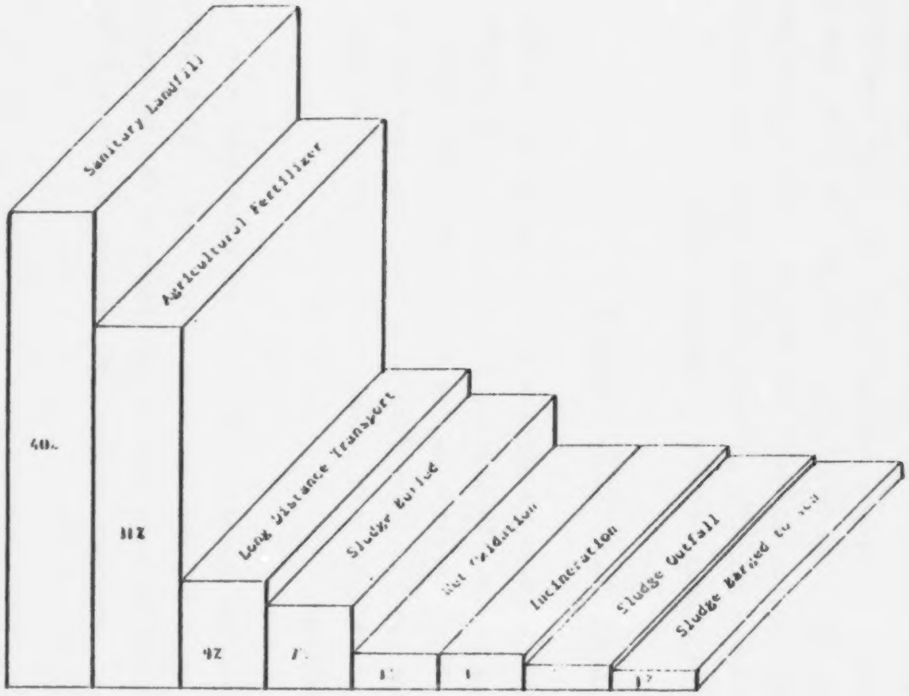


FIGURE B1-5. PERCENTAGE OF ALL POTWs REPORTING VARIOUS TYPES OF SLUDGE DISPOSAL METHODS

with hydraulic overloads, and 28% a problem associated with organic overloads.

Table B1-III lists similar information for POTWs that receive industrial waste. Of these POTWs, 77% have a problem associated with hydraulic overloads. Significantly, 42% report a problem with organic overloads, as compared to only 28% of all of the POTWs in the O&M data base.

The distribution of the overload causes for all POTWs is shown in Figure B1-6. While infiltration accounts for two-thirds of the overloads for all POTWs, industrial growth, increased service area, and rapid population growth each account for about 9% of the overloads. For the 330 POTWs that receive industrial waste, infiltration accounts for only 35% of the overloads, and industrial growth accounts for 25%. Figure B1-7 provides the distribution of overload causes for POTWs that receive industrial waste.

O&M Problems and Deficiencies Reported by POTWs

O&M problems at POTWs have an adverse effect on the performance of the plant. These problems include laboratory control, lack of personnel training, and inadequate spare parts inventories, as well as problems caused by industrial discharges. For the 330 POTWs reporting that they receive industrial waste, O&M problems associated with industrial waste are cited more frequently than any other O&M problem.

Most of the POTWs that report an O&M problem associated with industrial waste receive less than 5 MGD average daily flow. Figure B1-8 provides the distribution of POTWs in the data base which report an O&M problem associated with industrial waste. Of these plants, 79% receive less than 5 MGD average daily flow.

Figure B1-9 provides the percentage distribution of POTWs receiving industrial waste which report an O&M problem associated with an industrial waste. Of the 330 POTWs that receive industrial waste, 72% report an O&M problem associated with that waste.

TABLE B1-II

Percentage of All POTWS Reporting Various Types of Overloads

Overload Type	Major Problem	Minor Problem	Total	
Periodic Hydraulic	38%	24%	62%	74%
Continuous Hydraulic	7%	5%	12%	
Periodic Organic	8%	9%	17%	28%
Continuous Organic	6%	5%	11%	

TABLE B1-III

Percentage of All POTWs Which Receive Industrial Waste Report Various Types of Overloads

Overload Type	Major Problem	Minor Problem	Total	
Periodic Hydraulic	42%	25%	67%	77%
Continuous Hydraulic	5%	5%	10%	
Periodic Organic	18%	9%	27%	42%
Continuous Organic	12%	3%	15%	

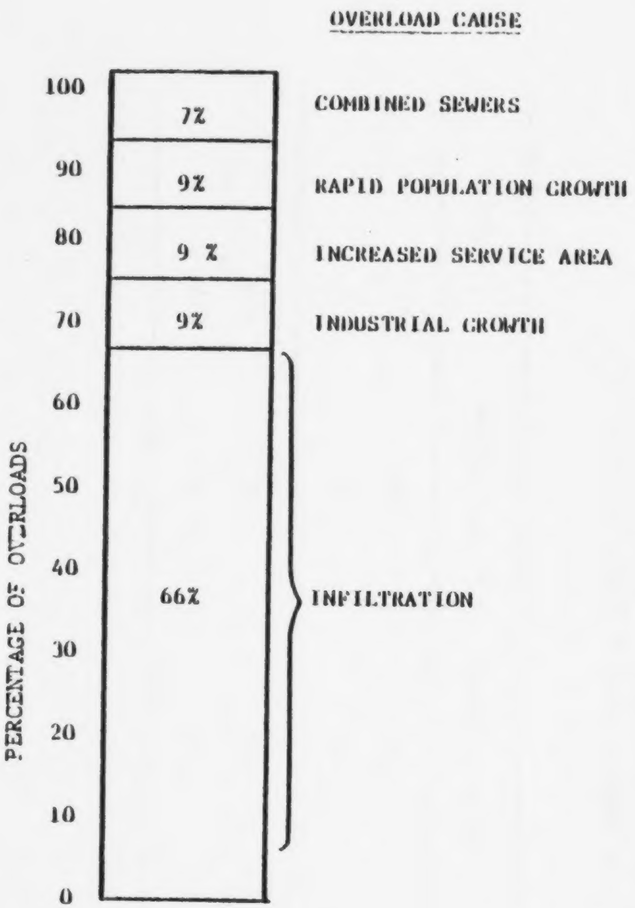


FIGURE B1-6. DISTRIBUTION OF THE CAUSES OF HYDRAULIC AND ORGANIC OVERLOADS FOR ALL POTWS.

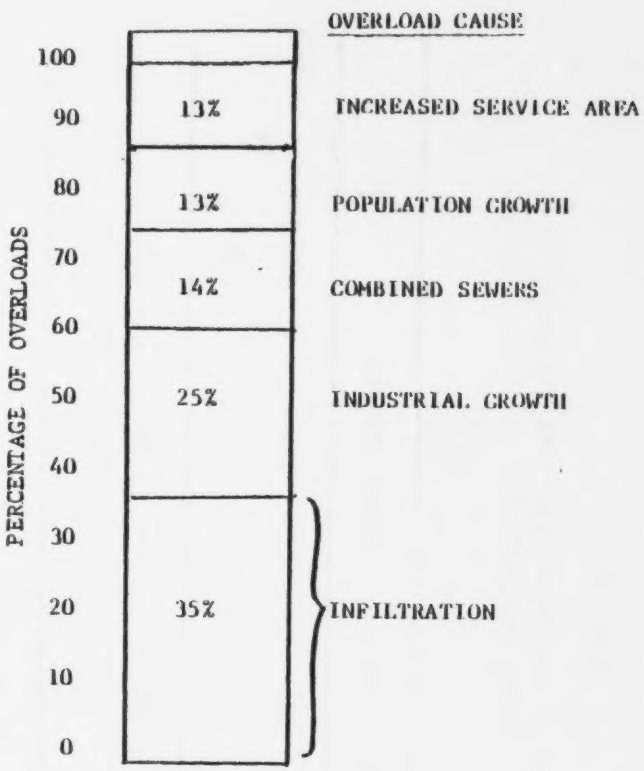


FIGURE B1-7. DISTRIBUTION OF THE CAUSES OF HYDRAULIC AND ORGANIC OVERLOADS FOR POTWS WHICH RECEIVE INDUSTRIAL WASTE.

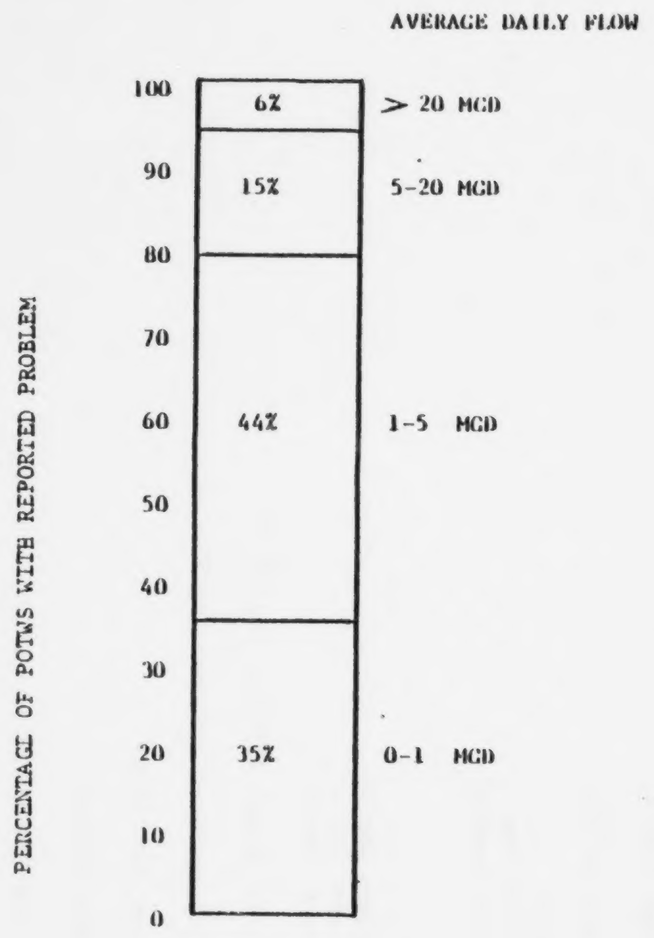


FIGURE B1-9. DISTRIBUTION OF POTWS REPORTING AN O&M PROBLEM ASSOCIATED WITH INDUSTRIAL WASTE

Figure B1-10 provides information on secondary POTWs reporting this problem as a percent of all POTWs in the seven categories of average daily flow. While the percent of the smallest size POTWs reporting the problem is low, the percentage increases up to POTWs receiving not more than 100 MGD. This suggests that the industrial waste O&M problems are common to most POTWs.

NPDES Permit Compliance

The inspections of POTWs are made to ensure compliance with the requirements of NPDES permits and construction grants. The factors used to assess plant performance and NPDES permit or construction grant compliance are:

- Monthly average flow (MGD)
- Maximum daily peak flow (MGD)
- Settleable solids
    - influent (mg/l)
    - effluent (mg/l)
    - percent removal
- Suspended solids
    - influent (mg/l)
    - effluent (mg/l)
    - percent removal
- BOD
    - influent (mg/l)
    - effluent (mg/l)
    - percent removal
- Dissolved oxygen effluent (mg/l)
- Chlorine residual effluent (mg/l)
- Coliform per 100 ml
- pH range effluent
- Total phosphorous
    - influent (mg/l)
    - effluent (mg/l)
    - percent removal

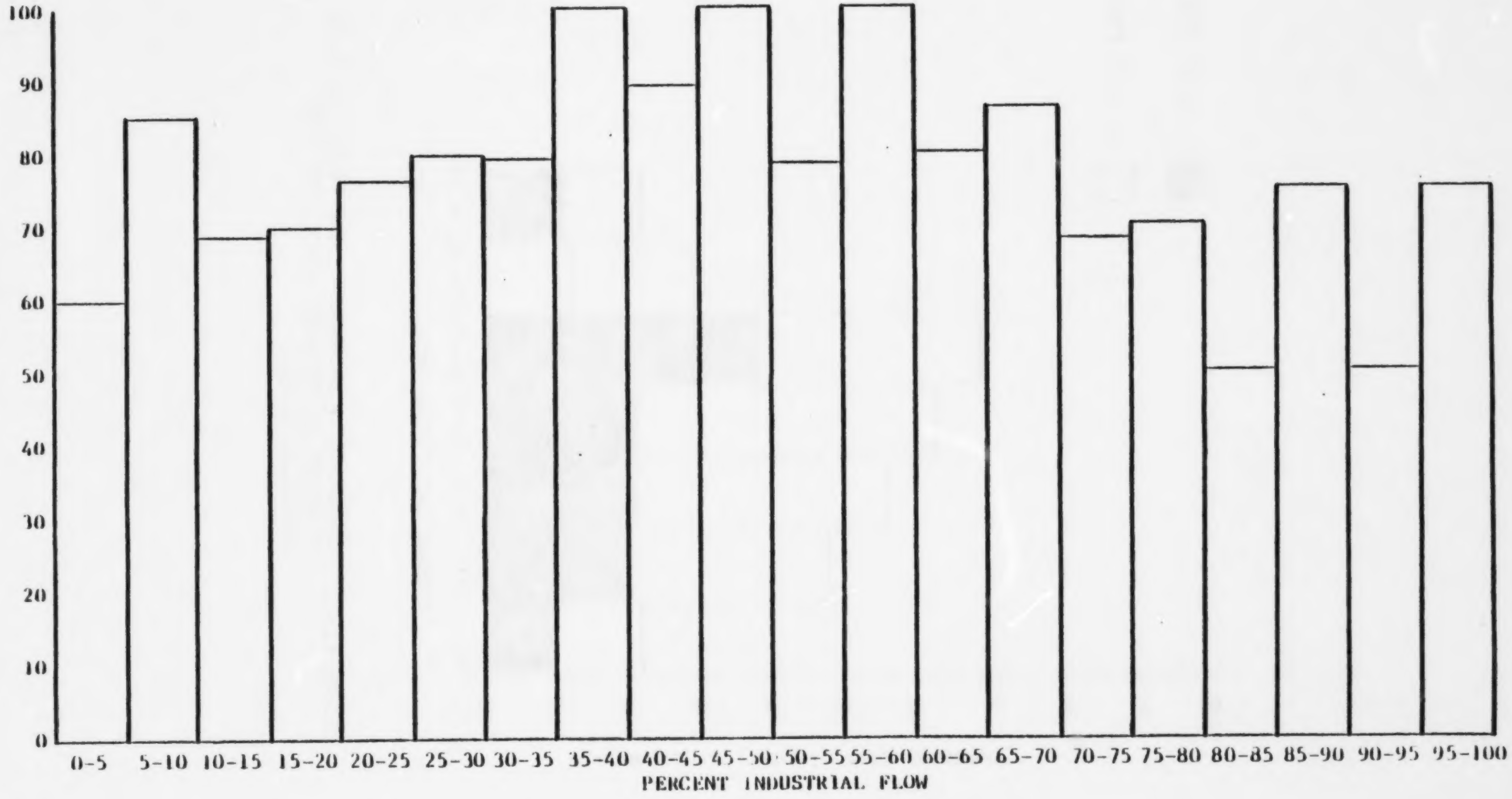


FIGURE B1-10. PERCENTAGE OF POTWs RECEIVING INDUSTRIAL WASTE REPORTING AN O & M PROBLEM ASSOCIATED WITH INDUSTRIAL WASTE

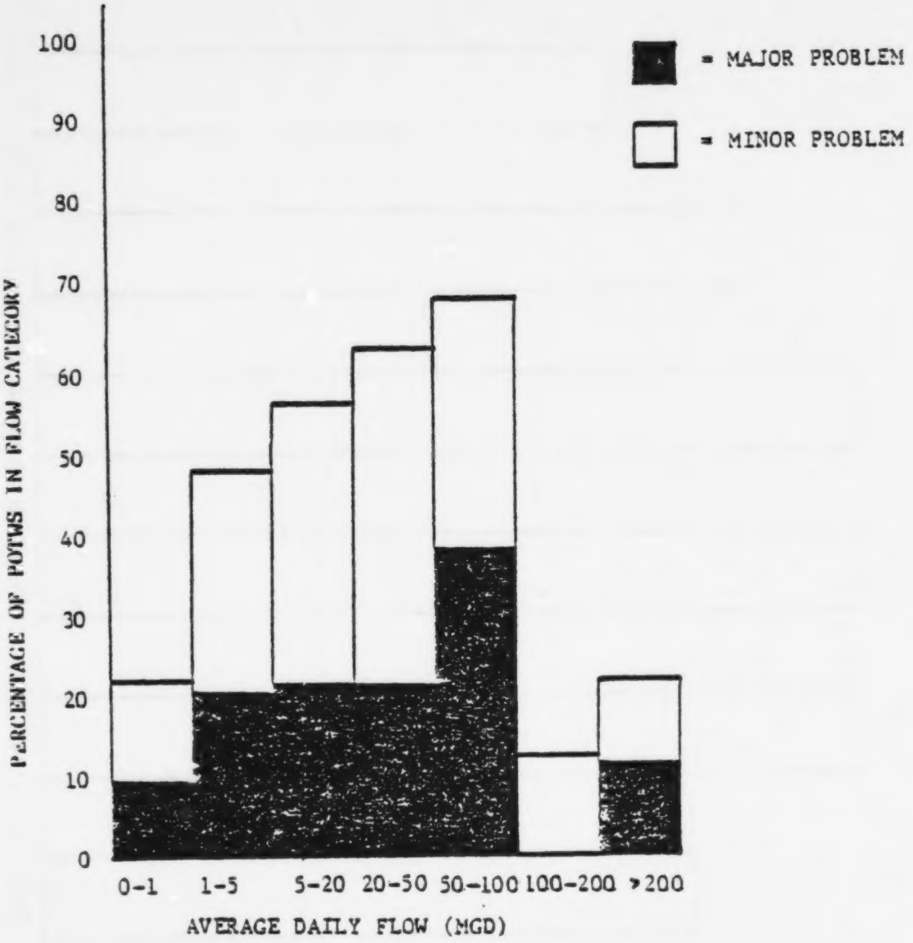


FIGURE B1-11. PERCENTAGE OF SECONDARY POTWS REPORTING MAJOR AND MINOR O&M PROBLEMS ASSOCIATED WITH INDUSTRIAL WASTE

- Total nitrogen
  - influent (mg/l)
  - effluent (mg/l)
  - percent removal.

Plants that reported an O&M problem associated with industrial waste were examined for compliance status with permits and construction grants requirements. More than 60% of the POTWs that report an O&M problem associated with industrial waste also did not meet at least one of their permit requirements. Of the 189 POTWs that reported an O&M problem with industrial waste and that did not meet at least one of their permit requirements, 70% receive less than 5 MGD average daily flow. Using categories of percent industrial flow, POTWs that reported the industrial waste O&M problem and that did not meet at least one of the permit requirements were examined. Figure B1-11 presents the results of this examination. The point is that the percentage of industrial wastes to a POTW is not an important parameter for determining O&M problems and violations of NPDES permits.

Sources of Industrial Discharges to POTWs

The O&M data base contains information on the principal types of industrial waste discharged to the municipal systems. Not all POTWs that report an O&M problem associated with industrial waste are able to specify either the source or the volume of the waste; a possible explanaion is that these POTWs have not yet conducted an industrial waste survey. Other POTWs responded with more than one source of industrial discharges. The narrative responses of the POTWs have been entered into the data base using four digit SIC codes. A total of 383 industries discharge waste to POTWs that report the O&M problem. Because the POTW may receive industrial waste from more than one source, the frequency distribution of industrial sources includes double counting. The most frequent sources of industrial waste to POTWs that report an O&M problem associated with industrial waste and the number of times reported, are:

- Textile goods, not elsewhere classified (50)
- Electroplating, plating, polishing, anodizing, and coloring (30)
- Chemicals and allied products (20)

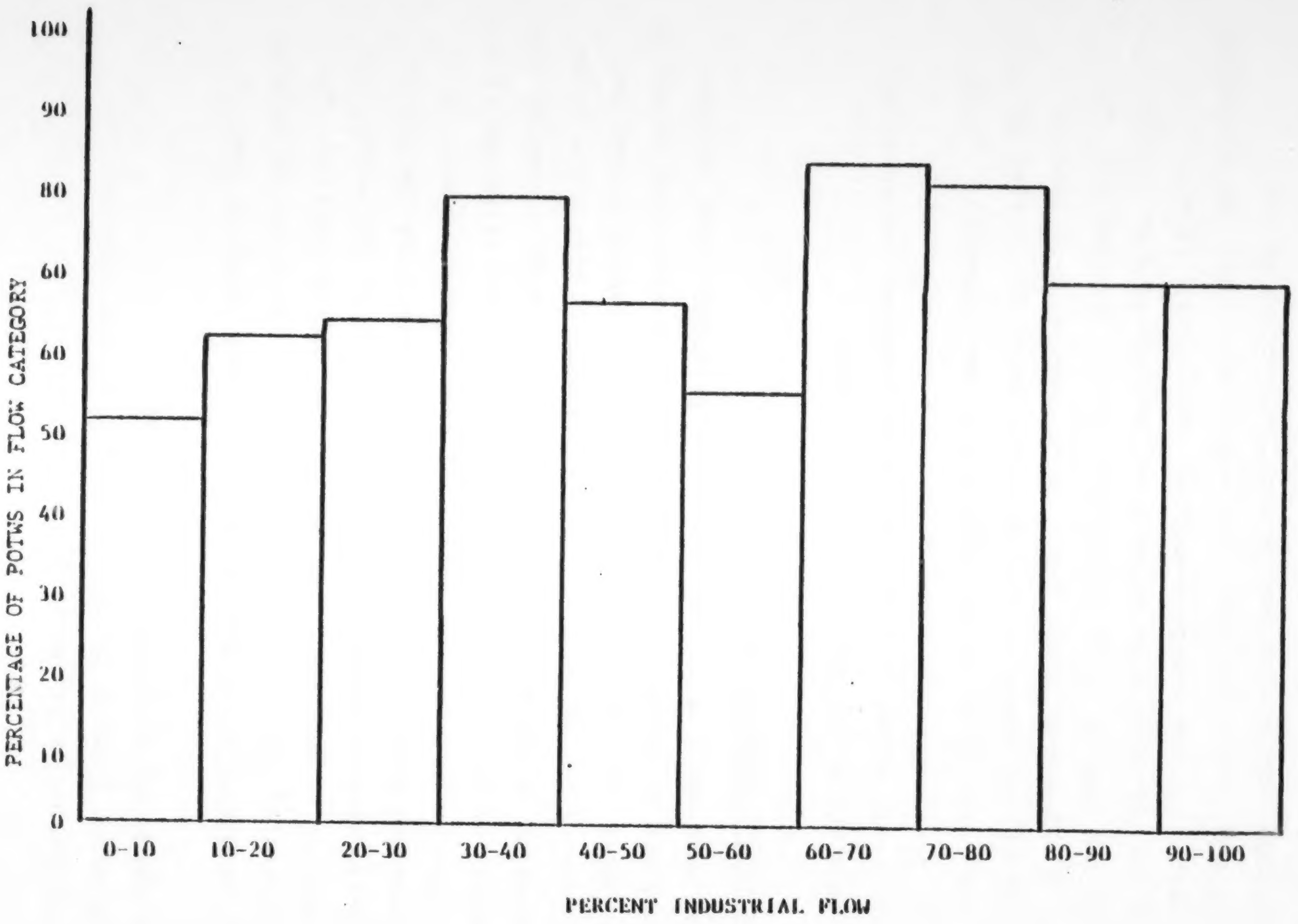


FIGURE B1-12. PERCENTAGE OF POTWS IN FLOW CATEGORY REPORTING AN O&M PROBLEM ASSOCIATED WITH INDUSTRIAL WASTE AND NOT MEETING ANY OF THE NPDES REQUIREMENTS

- Industrial machinery and equipment (15)
- General contractors - industrial buildings and warehouses (14)
- Scrap and waste materials (14)
- Power laundries, family and commercial (14)
- Restaurants (12)
- Meat packing plants (11)
- Poultry and egg processing (9).

These industrial sources reflect the four-digit SIC codes contained in the O&M data base. If a more general accounting of industrial waste discharges into POTWs with the O&M problem is desired, the three-digit SIC industrial groupings can be used. This ranking is, of course, less specific; it does however, tend to validate the four-digit rankings. There is some reordering of the frequency distribution and there are several new industrial waste sources. The most frequent three-digit groups of industrial waste sources discharging to POTWs that have an O&M problem associated with that waste, and the number of times reported, are:

- Miscellaneous textile goods (51)
- Coating, engraving, and allied services (30)
- Meat products (26)
- Groceries and related products (22)
- Machinery, equipment, and supplies (20)
- Chemicals and allied products (20)
- Miscellaneous durable goods (15)
- General building contractors--nonresidential buildings (14)
- Laundry, cleaning, and garment services (14)
- Dairy products (12)
- Miscellaneous nondurable goods (12).

B-2. ASSESSMENT OF 132 LOCAL INDUSTRIAL WASTEWATER CONTROL PROGRAMS

DESCRIPTION

JRB performed a statistical assessment of industrial wastewater control programs in selected municipalities to assess the local progress made in controlling industrial discharges to POTWs (Saltzberg, 1981). The assessment consisted of studying 132 municipal authorities that operated 294 plants. The POTWs included in the assessment were a statistically significant sample of the approximately 2,000 POTWs that are required to develop local pretreatment programs. The results of the study sample yielded results about the universe of POTWs with an error of ± 30%.

The data sought in the study were

- General facility data
- Industrial waste survey information
- Information on industrial users and industries regulated
- Legal authority for local programs
- Formal pretreatment programs and motivations for programs
- Industrial controls
- NPDES permit information.

CHARACTERISTICS OF POTWS IN THE ASSESSMENT

Of the 132 POTWs in the assessment, 51% received average flows equal to or less than 5 MGD, and 49% received flows greater than 5 MGD. Close to three-quarters of the municipalities reported secondary treatment as the highest level of treatment provided. Of the remaining municipalities, 17% percent provided tertiary treatment and 10% provided only primary treatment. Approximately 17% of the POTWs indicated that operations are most frequently carried out at or above design capacity.

Industrial flows to these POTWs varied with the size of the plant. For POTWs that received average flows equal to or less than 5 MGD, 49% received less than 10% industrial flow. For the larger POTWs, 41% received less than 10% industrial flow. A profile of the percentage of industrial flows for all POTWs in the assessment is provided in Table B2-I.

TABLE B2-I. DISTRIBUTION OF INDUSTRIAL FLOWS TO POTWS

Percent of Industrial Flow Received	Percent of POTWs
0-10	44
11-25	23
26-50	14
51-75	9
76-100	2
No response	8

SUMMARY OF CONCLUSIONS AND FINDINGS FROM THE ASSESSMENT

The conclusions and findings from the assessment are summarized below, and are discussed fully in the following sections:

- Of the 132 municipalities, 36% have not yet conducted an industrial waste survey.
- Of the municipalities that have conducted industrial waste surveys, 73% have taken some action toward establishing a local pretreatment program.
- Of the 120 municipalities that reported the total number of industries connected to the sewerage system, 41% receive waste from 26 or more industries.

- The industry-related problems reported by the all municipalities in the assessment are, in descending frequency of occurrence:
    - Interference (38% of total problems)
    - Passthrough (28% of total problems)
    - Sludge contamination (18% of total problems)
    - Other (16% of total problems; overloads and coloration problems were most frequently cited).
- Of the municipalities with POTWs greater than 5 MGD and that reported at least one industry related problem, only 11% have taken no action toward establishing a pretreatment program; of the municipalities with smaller POTWs, 59% have taken no action.
- Of the 63 municipalities with no industry-related problems, 64% had local permits or ordinances that restricted industrial discharges; of these municipalities, 63% regulated all local industry.
- Only 25% of the POTWs have the essential mechanisms in place to control industrial wastes (ordinance, permits, and enforcement).
- The motivations cited for developing a local control or a formal pretreatment program are:
    - Protection of POTW Operations (27%)
    - POTW Cost Recovery (8%)
    - Water Quality Improvement (8%)
    - Sludge Quality Improvement (6%)
    - POTW Worker Health & Safety (1%)
    - State or Federal Requirement (38%)
    - No Response (12%)
- Of all the municipalities, 94% had NPDES permits that controlled conventional pollutants; 87% of the permits did not address metals and 85% did not address toxic organics.

Industrial Waste Surveys

Of the 132 municipalities in the assessment, 36% have not yet conducted an industrial waste survey. Municipalities with POTWs that receive average flows equal to or less than 5 MGD accounted for 70% of the municipalities that have not conducted industrial waste surveys. Of those that have conducted surveys, 86% conducted them after the passage of the Clean Water Act of 1977.

In general, municipalities that conducted industrial waste surveys, or that were in the actual process of conducting surveys at the time of this study, had taken some action toward establishing a pretreatment program. Of the municipalities with plants larger than 5 MGD that conducted surveys, 89% were in the pretreatment program planning, development, implementation, or approval stage. Only 55% of the municipalities with smaller plants that conducted surveys had taken action toward establishing a local program. Overall, 73% of the municipalities that conducted industrial waste surveys reported some action toward establishing a local pretreatment program.

Industrial Users

Of the 120 municipalities that reported the total number of industries connected to the sewerage system, 41% received waste from 26 or more industries. The distribution of the number of industries connected to the sewerage systems of the municipalities is provided in Table B2-II.

TABLE B2-II. DISTRIBUTION OF THE NUMBER OF INDUSTRIES SERVED BY INDIVIDUAL POTWS

Number of Industries	Percent of Municipalities
0-10	46
11-25	13
26-50	13
51-75	1
76-100	6
>100	21

Of the municipalities that reported no problems related to industrial discharges, the mean number of industries connected to the sewerage system is 91; the range was between 0 and 2,250 industries. Of the municipalities that reported at least one industry-related problem, the mean number of industries connected was 220; the range was between 1 and 4,000 industries.

Industry-Related Problems

At least one industry-related problem was reported by 43% of the municipalities with POTWs receiving average flows equal to or less than 5 MGD. Of the municipalities with larger POTWs, 57% reported at least one industry-related problem. Of all the POTWs assessed, 66% of the POTWs that received between 11 and 50% industrial flow reported at least one problem.

The distribution of the types of problems reported is provided in Table B2-III.

TABLE B2-III.

DISTRIBUTION OF THE TYPES OF PROBLEMS RELATED TO INDUSTRY

Problem	Percent of Total Problems
Interference	38%
Passthrough	28%
Sludge Contamination	18%
Other	16%

Seventeen percent of the municipalities reported that they experienced two or more problems. Of those that reported other problems, overloads and coloration were most frequently cited. Corrosion in pumps, foaming, oil and grease, and plating wastes accumulating in the anaerobic digestor were also cited. When asked specifically whether these problems caused a NPDES permit violation, 42% said no, 36% said yes, 19% did not know, and 3% prefered not to respond.

There are apparent differences in the way municipalities have responded to identified problems related to industrial discharges. Of municipalities with POTWs that receive average flows greater than 5 MGD, only 11% have taken no action toward establishing a pretreatment program. However, of the municipalities with small POTWs and with at least one problem, 59% have taken no action toward controlling industrial discharges.

Of the municipalities that have large POTWs and that have no reported problems related to industrial discharges, 74% have permits or ordinances restricting waste. For the smaller POTWs with no problems, 56% use permits or ordinances to regulate discharges to the sewerage system. Overall, 64% of the municipalities with no identified problems have permits or ordinances to restrict industrial discharges. Of this number of municipalities, 63% regulate all the local industry.

Local Control and Formal Pretreatment Programs

POTWs were requested to answer several specific questions regarding their initiations in controlling industrial waste. First, POTWs were asked whether there was a sewer use ordinance with specific effluent limits; second, they were asked whether there was a mechanism to grant permits to industrial users; finally, they were asked whether there was monitoring and enforcement of the program. These three elements are considered essential to a basic local industrial waste control program. Table B2-IV shows that only 25% of the municipalities have these essential mechanisms in place.

The second question addressed the status of formal pretreatment programs, developed in accordance with the General Pretreatment Regulations.
Of the municipalities that reported the status of their formal pretreatment program, only 12% had applied for approval or were in the implementation stage. Table B2-V provides the status of formal pretreatment programs for the

TABLE B2-IV.

LOCAL CONTROL PROGRAM IN PLACE

Pretreatment in Place (Ordinance, Permits, and Enforcement)	POTWs with >5 MGD FLOW (n = 65)	POTWs with <5 MGD Flow (n = 67)	Total (n = 132)
Yes	31%	18%	25%
No	66	75	70
Unknown	3	7	5
	100%	100%	100%

TABLE B2-V.

FORMAL PRETREATMENT PROGRAM STATUS

Level of Effort	Percentage of Municipalities with POTWs >5 MGD	Percentage of Municipalities with POTWs ≤5 MGD	Percentage of all Municipalities
Planning	34	24	29
Developing	28	6	17
Implementing	5	3	4
Applied for Approval	12	3	8
No action	21	57	39
No response	0	7	3

municipalities in the assessment. Only 21% of the 65 municipalities that had plants with flows above 5 MGD had taken no action, but 57% of the 67 municipalities with smaller plants had taken no action.

In addition, municipalities were asked to cite their motivation for developing either a local control program or a formal pretreatment program. Table B2-VI provides the distribution of the responses on motivation for developing programs. Because several responses to the question of motivation were received from some POTWs, the percentages in Table B2-VII represent the percent of all responses received, not a percent of all POTWs.

TABLE B2-VI.

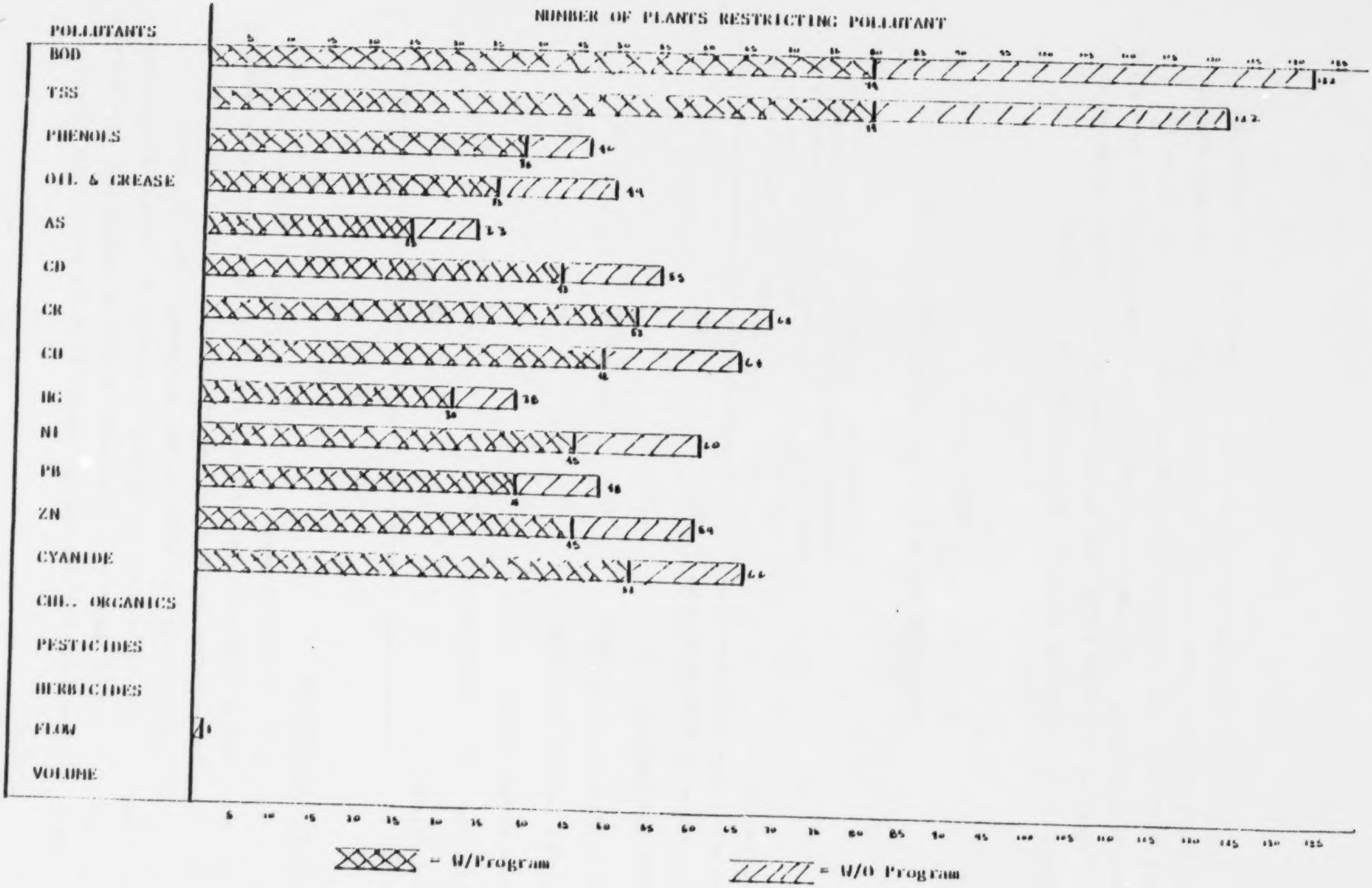
MOTIVATION FOR DEVELOPING PRETREATMENT PROGRAMS

Motivation	Percentage of Responses from Municipalities with POTWs >5 mgd	Percentage of Responses from Municipalities with POTWs ≤5 mgd	Percentage of Responses from all Municipalities
Protection of POTW Operations	24%	30%	27%
POTW Cost Recovery	13%	0	8%
Water Quality Improvement	9%	7%	8%
Sludge Quality Improvement	9%	2%	6%
POTW Worker Health & Safety	1%	0	1%
State or Federal Requirement	38%	37%	38%
No Response	6%	24%	12%

Industrial Controls

Municipalities were requested to provide information on specific industrial limits that exist set by local ordinance and permit mechanisms, and on monitoring performed by the POTWs and by industry. Figure B2-1 shows the pollutants restricted at the POTWs in the assessment. For evaluation purposes, municipalities that had adopted an ordinance, issued permits, and monitored industrial users were considered to have an operational pretreatment program. Figure B2-2 provides the percentage of POTWs regulating specific

FIGURE B2-1.



NUMBER OF PLANTS RESTRICTING POLLUTANT
POLLUTANTS
BOD
TSS
PHENOLS
OIL & GREASE
AS
CD
CR
CU
HG
NI
PB
ZN
CYANIDE
CHL. ORGANICS
PESTICIDES
HERBICIDES
FLOW
VOLUME
142
49
23
55
68
64
38
30
60
45
48
64
45
66
= W/Program
= W/O Program

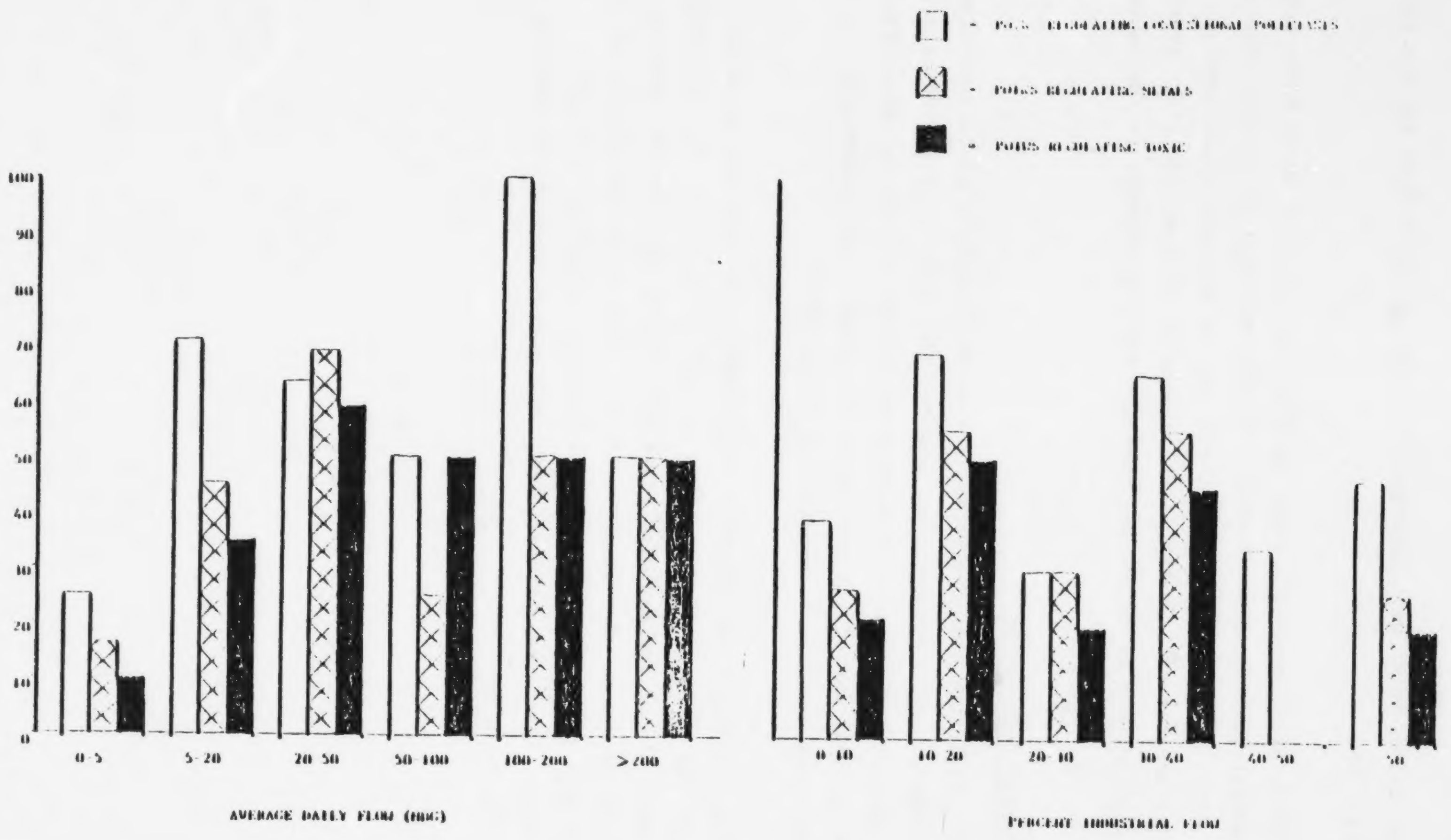


FIGURE B2-2. PERCENT OF POTWS REGULATING SPECIFIC POLLUTANT TYPES BY AVERAGE DAILY FLOW AND PERCENT INDUSTRIAL FLOW

pollutant types, which were aggregated by average daily flow and percent industrial flow.

A total of 31 municipalities, or 23%, reported that their POTWs conduct no industrial compliance monitoring. For conventional pollutants, metals, and toxics, 41%, 36%, and 32%, respectively, of the municipalities conduct compliance monitoring. Twenty eight percent of the municipalities report that their local industries do not self-monitor their discharges to the sewerage system.

NPDES Permit Information

Only 3% of the municipalities have no NPDES permit limits specified for conventional, metal, and toxic pollutants. For individual pollutant types, 6% of the municipalities had no conventional limits, 87% had no metal limits, and 85% had no toxic limits. A profile of the NPDES permit parameters for the municipalities assessed is provided in Table B2-VII.

Five municipalities reported violations of at least one parameter in the NPDES permits to occur as frequently as 100% of the time. For conventional pollutants, 31% of the municipalities with permit limitations reported that no violations occurred. For metal pollutants, 25% of the municipalities with permit limitations reported that no violations occurred. For toxic pollutants, 14% of the municipalities with permit limitations reported that no violations occurred.

TABLE B2-VII.

PARAMETERS LISTED IN NPDES PERMITS

Pollutant	Number of Limits in Permit	Percent of Municipalities with Specified Limits
Conventional	None	5
	More than 1	96
Metal	None	87
	1-3	2
	4-6	0
	More than 6	8
Toxic	None	85
	1-3	8
	4-6	1
	More than 6	3
No Pollutants	No limits	3

Receiving Waters

POTWs in the asssessment were asked the type of receiving water to which they discharge and the use of that receiving body. In general, POTWs responded with multiple answers to the use question. Rivers and creeks were cited as the receiving body by 82% of the POTWs; of the plants receiving less than 5 MGD average flow, 95% discharge effluent to rivers and creeks. Table B2-VIII presents the distribution of the types of receiving waters to which the POTWs discharge.

Table B2-IX presents the distribution of the uses of the receiving water.

TABLE B2-VIII
DISTRIBUTION OF RECEIVING BODIES

TYPE OF RECEIVING WATER	% OF POTWS ≤ 5MGD	% OF POTWS >5MGD	% OF ALL POTWS
Rivers & Creeks	95%	71%	82%
Oceans, Bays, & Estuaries	0	15%	8%
Lakes	0	9%	4%
Channels & Bayous	0	4%	2%
Settling Ponds	1%	0	1%
No Response	4%	2%	3%

Because many of these waters are typified by general uses, the responses shown in the table are the percentages of the total responses. The most frequently occurring response, from both large & small POTWs, was recreational water use.

TABLE B2-IX
DISTRIBUTION OF RECEIVING WATER USES

USE	% OF RESPONSES FROM POTWS ≤ 5MGD	% OF RESPONSES FROM POTWS > 5MGD	% OF TOTAL
Recreation	29%	38%	34%
Water Supply	16	22	19
Commercial Shipping	3	11	7
Agriculture	6	4	5
Fish and/or Wildlife Refuge or Preserve	6	4	5
Drainage	6	2	4
Industrial	2	2	2
Commercial Fishing and/or Shell Fishing	0	4	2
Negligible Use*	16	2	9
No Response	16	11	13

*The most common response categorized as "negligible use" was that the receiving body "is not used for much." Further questions indicated that stream flow is minimal, or too intermitent in nature to sustain a qualifiable use.

B-3. 77 POTW VISITS' SUMMARY

JRB Associates and several subcontractors provided technical assistance to 77 POTWs from 1979 to 1980 (U.S. EPA 1979). Candidate POTWs were selected, after screening, from a list identified by EPA Regional Offices and NPDES States. Assistance involved evaluating and recommending, as appropriate, the need for local pretreatment program development. The POTWs covered in this assistance program were distributed over 22 States and all of the EPA Regions, except Region X. A report was prepared on each POTW which included a review of the plant operations, performance data, and discussions with POTW personnel on operating conditions and problems. Major nondomestic users of each POTW were visited to determine the quantity and origin of pollutants entering the POTW. Each report reviews the sewer-use ordinance of each POTW in terms of specific legal authority requirements under 40 CFR 403.

This data base was analyzed and is presented in this section of Appendix B. The analysis included POTW operational problems, distribution of categorical and noncategorical industries discharging to the POTWs, the specific impact of electroplating and food processing discharges, and industrial discharge limit setting and monitoring/enforcement practices. Pertinent conclusions drawn from this analysis are presented below.

- Operational Problems
    - 84% of process upsets are reported to be caused by industrial discharges.
    - 66% of the POTWs periodically violate their NPDES permit limits.
    - 65% of these violations are reported to be caused by industrial discharges.
    - 19% of the POTWs have had heavy metal sludge contamination problems.
    - 87% of the POTWs reporting a known sludge contamination condition attribute it to industrial discharges.

- o Industrial Distribution
  - The food processing (51% of the POTWs have at least one such discharge) electroplating (40%), mechanical products (35%), and textiles (16%) industries were the most prevalent industrial discharges found.
  - 46% of the food processors, 50-64% of the electroplaters, 34% of the mechanical products firms, and 7% of the textile industries that discharge to POTWs provide some form of pretreatment.
- o Impact of Electroplaters and Food Processors
  - POTWs receiving electroplating discharges indicated four times the known sludge contamination incidence as those POTWs that do not receive electroplating discharges.
  - POTWs receiving electroplating discharges indicated two times the process upsets as those POTWs that do not receive electroplating discharges.
  - POTWs receiving food processing discharges indicated over twice as many NPDES violations for residual chlorine and/or fecal coliform as those POTWs not receiving food processing discharges.
  - POTWs receiving food processing discharges indicated twice as many biological and sedimentation process upsets.
- o Limit Setting and Monitoring/Enforcement
  - 19% of the POTWs have no limits on conventional pollutants, 47% have no limits on metals, and 57% have no limits on toxics.
  - 68% of the POTWs do not monitor or enforce their industrial users on a regular basis (at least once a year).
  - 12% of the POTWs monitor for metals and 1.3% monitor for toxics.
  - Approximately 30% of the POTWs have never performed a sludge analysis.

BACKGROUND

Technical assistance in developing local pretreatment programs was provided to 77 POTWs from 1979 through 1980. JRB Associates and several subcontractors provided this assistance through a contract with Environmental Protection Agency Office of Water Enforcement (EPA-OWE, EPA contract No. 68-01-5052). Candidate POTWs were identified by EPA Regional Offices and the NPDES states. JRB contacted the candidate POTWs by phone and screened out those POTWs that were not interested in assistance, that received little or no industrial wastewater flows, and/or that were in the process of developing their local pretreatment with 201 Grant assistance. The POTWs selected were distributed over 22 states and all EPA Regions, with the exception of Region X.

An engineering team visited each POTW selected, reviewed plant operations and performance data, and discussed operating conditions and problems with POTW personnel. Major nondomestic dischargers to each POTW were also contacted to determine the quantity and origin of pollutants that may interfere with or pass through the POTW. Copies of pertinent data including monitoring reports, financial reports, and POTW sewer-use ordinances were provided to the team so that it could evaluate the POTW and determine local pretreatment program needs.

A technical report was prepared for each POTW visited, describing the POTW, the major nondomestic users, and any existing problems. Each report included recommended pollutant discharge limits, suggested solutions to operating problems, evaluation of the local sewer use ordinance with respect to pretreatment legal authority requirements, a summary of the local situation, and where warranted, a recommended a local pretreatment program. The following data and conclusions have been developed from an overall review and analysis of the 77 POTW reports comprising this data base.

This analysis was conducted to gain insight into the following questions.

- To what extent are the 77 small POTWs experiencing operating problems?
- Do industrial discharges appear to be contributing to POTW operating problems?
- How are the industries that are considered to be possible sources of problem pollutants distributed among the 77 POTWs?
- How many of the these industries are presently pretreating their wastewater?
- Do certain POTW operating problems appear to be related to the presence of specific types of industrial wastes?
- How many of the 77 POTWs have established specific pollutant limits?

- o How many of the 77 POTWs are presently monitoring their industrial users?

The data base was analyzed by observing operational problems (including NPDES permit violations, industrial user problems, sludge contamination, and process upsets) distribution of industries using POTWs, impact of specific users (electroplaters, food processors), discharge limits, and monitoring/ enforcement practices. The results of this analysis are presented below.

OPERATIONAL PROBLEMS

The 77 reports were reviewed to determine the extent to which the POTWs were experiencing operating problems. Problems were classified into three types: NPDES violations, sludge contamination, and plant upsets. The NPDES violations category was subdivided into three additional subcategories: biochemical oxygen demand (BOD) and/or suspended solids, residual chlorine and/or fecal coliforms, and "other" (pH, NH_3, P, metals, etc.). All of the POTWs that reported sludge contamination problems listed metals contaminants, with one POTW also reporting sludge containing a significant quantity of polychlorinated biphenyls (PCBs).

Because many POTWs have not yet analyzed their sludge for contaminants, the reports were also reviewed to determine which POTWs suspected sludge contamination and which POTWs needed to analyze their sludge. POTWs that used land application for final sludge disposal and those that had to change their final sludge disposal method due to contamination were also noted. Three major types of plant upsets were observed: sedimentation process upsets, biological process upsets, and sludge handling process upsets.

The number of POTWs that reported industrial discharges contributing to the three types of operating problems were recorded. To simplify the analysis, frequency of occurrence was not addressed, and only those problems that recurred at least yearly were recorded.

Table B3-I summarizes the operational problems discussed above. From this table the following conclusions were drawn:

- Two-thirds of the 77 POTWs experienced periodic NPDES violations for one or more pollutants.
- Most of these NPDES violations were for BOD and/or suspended solids.
- Nearly two-thirds of the POTWs experiencing NPDES violations reported that industrial waste contributed to the violations.
- Nearly one-fifth of the 77 POTWs have heavy metal concentrations in their sludge that are high enough for the sludge to be considered contaminated (i.e., not suitable for cropland or pasture application and that could create leachate problems in landfills).
- Over one-fifth of the 77 POTWs have not analyzed for contaminants in their sludge and probably should.
- Nearly one-fourth of those POTWs that should analyze their sludge are suspected to have sludge contamination as a result of the discharge of industrial wastewater containing heavy metals into their system.
- Of the POTWs with known sludge contamination 87% reported that industrial wastewater contributed to the contamination.
- Two-thirds of the POTWs with contaminated sludge have changed or will need to change their methods of final sludge disposal because of the contamination.
- Over one-third of the 77 POTWs practice land spreading as a method of final sludge disposal.
- One-fourth of the 77 POTWs are experiencing one or more types of process upsets.
- Of the POTWs experiencing process upsets, 84% reported that industrial wastewater contributed to the uspets.
- Biological process upsets were twice as prevalent as reports of sedimentation process upsets, and four times as prevalent reports of sludge-handling process upsets.

DISTRIBUTION AND PRETREATMENT OF INDUSTRIAL USERS

The food processing, electroplating, and mechanical products industries were the most prevalent industries listed in the 77 POTW reports as possible sources of problem pollutants. Generally, food processing wastewater has been considered to be compatible with POTW treatment processes. However, in many

TABLE B3-I

Reported Incidence Of POTW Operating Problems

	NPDES Violations					Sludge Contamination						Plant Upsets				
												Process Affected				
	BOD and/or SS	Cl and/or F. Coliforms	Other	Total No. of POTWs Violating	Reported as being Industry Related	Sludge Needs Analysis	Contamination Suspected	Contamination Known	Known Contam. Reportedly Caused by Industry	Contam. Affects Disposal Method	Practice Land Spread of Sludge	Sedimentation	Biological	Sludge Handling	Total POTWs with Upsets	Upset Reported as Caused by Industrial Wastes
# of POTW's	45	14	17	51	33	22	5	15	13	10	27	6	13	3	19	16
% of Total (77)	58%	18%	22%	66%	43%	29%	6%	19%	17%	13%	35%	8%	17%	4%	25%	21%
% of POTWs Experiencing Problem Listed	--	--	--	--	65%	--	23% of those that need analysis	--	67%	67%	--	--	--	--	--	84%

instances the quantity and strength of this wastewater has contributed to shock loadings and overloading of BOD, suspended solids, and oil and grease. Less than half of the food processors examined provide any form of pretreatment, indicating that a number of the 77 POTWs in this study may be receiving untreated wastewater from food processors. Some POTW operating problems could be attributable to these dischargers.

The electroplating industry is a known source of wastewater containing heavy metals, cyanide, and extreme pH values. At the time that the reports were written, only 50-64% of the electroplaters were pretreating their discharges to the POTWs. With the promulgation of the Electroplating Categorical Pretreatment Standards, the percent of electroplaters that pretreat their wastewaters should increase dramatically as the compliance date approaches. Until they begin to pretreat, electroplating wastewaters will continue to be a source of POTW operating problems.

The mechanical products industry consists of a wide variety of industrial processes and products. The fact that a large variety of industries fall into this category may be the main reason that so many POTWs reported that mechanical products industries may be a possible source of problem pollutants. Due to the variety of processes used, the pollutants discharged by these industries contain many different priority pollutants, including toxic organics and metals, suspended solids, extreme pH values and shock loads. Approximately two-thirds of the mechanical products industries listed in the 77 POTW reports do not pretreat their discharges. This indicates that a large number of the mechanical products industries discharging to the 77 POTWs do nothing to control pollutants in their discharges.

Distribution of Industries

Each report described the major nondomestic dischargers that the engineering team and the POTW staff considered to be possible sources of pollutants that might interfere with or pass through the POTW. Table B3-II shows the number of industries reported in each category and noncategorical group and the percent of industries in each group that provide some form of pretreatment prior to discharge to the POTW. Only the industries considered to

TABLE B3-II

DISTRIBUTION AND PRETREATMENT OF INDUSTRIAL USERS CATEGORICAL/NON-CATEGORICAL INDUSTRIES

Categorical Industry	Total Number of Industries	POTWs with Categorical/ Non-categorical Indirect Discharges		Industries that Pretreat	
		Number	Percent of 77 POTWs	Number	Percent
Adhesives	1	1	1.3	0	0
Aluminum Forming	2	2	2.6	1	50
Automatic and Other Laundries	16	11	14	6	38*
Electrical Products	5	5	3.9	4	80*
Electroplating	50	31	40	25+(7)**	50-64*
Foundries	6	5	6.5	2	33*
Inorganic Chemicals	3	3	3.9	2	67
Iron and Steel	3	3	3.9	0	0
Leather Tanning and Finishing	4	4	5.2	3	75
Mechanical Products	38	27	35	13	34*
Organic Chemicals	8	7	9.1	3	38*
Paint and Ink	4	3	3.9	2	50
Pesticides	1	1	1.3	1	100
Petroleum Refining	1	1	1.3	0	0
Pharmaceuticals	2	2	2.6	1	50
Photographic Supplies	1	1	1.3	1	100
Plastics and Synthetics	2	2	2.6	1	50
Plastics Processing	2	2	2.6	0	0
Printing and Publishing	3	3	3.9	0	0
Pulp, Paper, and Fiberboard	7	6	7.8	4	57*
Rubber	4	4	5.2	2	50
Soaps and Detergents	2	2	2.6	0	0
Textile Mills	14	12	16	1	7*
Timber Products Processing	1	1	1.3	0	0
Food Processors	52	39	51	24	46*
Hospitals	9	8	10	1	11*

TABLE B3-II (Continued)

DISTRIBUTION AND PRETREATMENT OF INDUSTRIAL USERS CATEGORICAL/NON-CATEGORICAL INDUSTRIES

Categorical Industry	Total Number of Industries	POTWs with Categorical/ Non-categorical Indirect Discharges		Industries that Pretreat	
		Number	Percent	Number	Percent
Septage Haulers	4	3	3.9	1	25
Photo Finishers	5	5	6.5	4	80* (mostly for Ag)
Waste Processor	1	1	1.3	0	0
Bottling	3	2	2.6	0	0
Glass Manufacturing	3	2	2.6	0	0

*Indicates percent of analysis included five or more industries.

**In one POTW, no pretreatment information was available for seven electroplaters.

be possible sources of problem pollutants are listed, not all of the industries that discharge to the POTWs. Therefore, the information in Table B3-11 cannot be used to determine the extent to which these industries are distributed throughout the 77 POTWs. However, the table can be used to assess the percentage of the reported industries that are pretreating.

The number of POTWs that reported one or more industries in each category or groups as possible sources of problem pollutants are listed below in descending order. Only those industrial categories or groups listed by five or more POTWs are presented.

Industrial Category or Group	No. of POTWs
Food Processing	39
Electroplating	31
Mechanical Products	27
Textile Mills	12
Automatic and Other Laundries	11
Hospitals	8
Organic Chemicals	7
Pump, Paper, and Fiberboard	6
Foundries	5
Photo Finishing	5

Pretreatment of Industrial Wastewater

The percentage of industries in each category or group that pretreat their wastewater before discharging to POTWs is presented below in descending order. Only those categories or groups with five or more industries are presented.

Industrial Category or Group	Percent of Industries That Pretreat
Photo Finishing	80
Electrical Products	80
Electroplating	50-64
Pulp, Paper, and Fiberboard	57
Food Processing	46
Organic Chemicals	38
Automatic and Other Laundries	38
Mechanical Products	34
Foundries	33
Hospitals	11
Textile Mills	7

IMPACT OF ELECTROPLATERS AND FOOD PROCESSORS

EPA has promulgated discharge limits for electroplaters that discharge to POTWs. Electroplaters have long been suspected as a major nondomestic source of metals entering POTWs. Another nondomestic discharger of major concern is the food processing industry. This industry group is not a primary industry, but its wastes enter a majority of U.S. POTWs and are a reported source of continuous and slug loads of high strength BOD, suspended solids, and grease entering POTWs. For these reasons, the 77 POTW data base was analyzed with respect to NPDES violations, plant upsets, and sludge contamination across POTWs with and without electroplating discharges and with and without food processing discharges. Table B3-III presents these two analyses. It should be noted that the data between industries cannot be compared directly. Results indicate the following trends:

- POTW NPDES violations do not seem to be directly associated with discharges from electroplaters.
- POTWs receiving electroplating discharges showed four times the known sludge contamination incidence as those POTWs not receiving electroplating discharges.

TABLE B3-III

PERCENT OF POTWS RECEIVING GIVEN INDUSTRIAL WASTEWATERS EXPERIENCING VARIOUS OPERATING PROBLEMS

	Number of POTW	NPDES Violations			Sludge Contamination		Plant Upsets			
		BOD and/or SS	Chlorine and/or Fecal Col.	Other: pH, NH, P, Metals	Suspected	Known	Sedimentation Processes	Biological Processes	Sludge Handling Processes	Total Process Upsets
POTWs Receiving Electroplating Wastewater	31	45%	13%	26%	32%	35%	10%	26%	6%	42%
POTWs Receiving No Electroplating Wastewater	46	67%	22%	20%	24%	9%	7%	11%	2%	20%
POTWs Receiving Food Processor Wastewater	40	60%	25%	18%	5%	10%	10%	23%	3%	35%
POTWs Receiving No Food Processor Wastewater	37	54%	11%	24%	5%	24%	5%	11%	5%	22%

- POTWs receiving electroplating discharges had two times the number of process upsets as those POTWs not receiving electroplating discharges.
- Although the proportion of POTWs reporting sludge handling problems was small, POTWs receiving electroplating discharges indicated over twice as many sludge handling process upsets.
- POTWs receiving food processing discharges indicated only a slightly higher incidence of NPDES violations for BOD and/or suspended solids than those POTWs receiving no food processing wastewater.
- POTWs receiving food processing discharges reported over twice as many NPDES violations for residual chlorine and/or fecal coliforms as those POTWs not receiving food processing discharges.
- POTWs receiving food processing discharges had twice as many biological and sedimentation process upsets.

SPECIFIC LIMITS AND MONITORING/ENFORCEMENT

The 77 reports were reviewed to determine whether the POTWs have specific limits for conventional pollutants (i.e., BOD suspended solids, NH_3, oil, and grease), metals, and toxic organics. Many POTWs that do limit pollutants do not set specific limits. Instead their requirements limit a given pollutant in sufficient quantity to interfere with POTW operations. The results of this review are presented in Table B3-IV.

The 77 reports were also reviewed to determine how many POTWs conduct compliance monitoring of industrial discharges and/or have taken enforcement actions against indusyrial dischargers. Any POTW that monitors industrial dischargers at least once a year was considered to be conducting compliance monitoring. The results of this review are presented in Table B3-V.

TABLE B3-IV.

DISTRIBUTION OF POTW LIMITS FOR CONVENTIONAL POLLUTANTS

	Percent of Pollutants		
	Conventional	Metals	Toxic Organics
Have Specific Limits	38	10	4
Have General or Specific Limits	82	53	43
Have No Limits	18	47	57

TABLE B3-V.

PERCENT OF 77 POTWS EXHIBITING COMPLIANCE MONITORING AND/OR ENFORCEMENT

Extent of Monitoring	Percentage
None	68
Conventional	32
Metals	12
Toxic Organics	1.3 (1 POTW)

From these two tables the following conclusions can be made:

- Over two-thirds of the 77 POTWs do not routinely monitor their industrial contributors
- Monitoring for toxic organic compounds is almost nonexistent (only one of the 77 POTWs), while 43% of the POTWs have at least general limits on one or more of these compounds.
- Only 12% of the 77 POTW's monitor industrial contributors for metals, while 53% have at least general limits for one or more metals.
- Roughly one-third of the 77 POTWs routinely monitor their industrial contributors for conventional pollutants, while four-fifths have at least general pollutant limits.

B-4. 40 POTW STUDY SUMMARY

This study was conducted by the EPA Office of Water Regulations and Standards, Effluent Guidelines Division, and focused on 40 POTWs providing at least secondary treatment. Data collection for the 40 POTW Toxic Study (1978-1980) has been completed. An intensive week-long sampling program was conducted at each POTW to determine the occurrence and fate of priority pollutants. This section presents a detailed analysis of the data (Feiler 1980, Southworth 1981). Conclusions that can be drawn from this analysis are summarized below:

- Among the 40 POTWs studied, industry was found to be a significant contributor of priority pollutants to POTWs. Variations in priority pollutant concentrations can be attributed to the type and size of industry discharging into the POTW.
- Approximately 15 organics, 8 heavy metals, and cyanide were found consistently in POTW influents.
- POTWs that meet secondary treatment requirements provide good removal of priority pollutants. Generally, these POTWs remove approximately 75% of the heavy metals, 80% of the total volatile organics, and 70% of the total acid-base-neutral organic pollutants. Removals vary for individual pollutants.
- POTW removal efficiency was found to be independent of the influent pollutant concentration.
- POTWs that have pretreatment programs have lower concentrations of priority pollutants in the POTW influent and effluent. For example, total metals were 28% higher in influent that had no pretreatment and 24% higher in effluents. These trends carried through for acid-base neutrals--76% and 59%, and for volatiles--315% and 299% for influent and effluent, respectively.
- Priority pollutant metals removed at POTWs are incorporated into the waste sludge.
- A significant portion of the volatile priority pollutants are air-stripped during the treatment process, and consequently do not appear in the sludge.

B-4. 40 POTW STUDY

DESCRIPTION

From 1978 to 1980 the Effluent Guidelines Division embarked on a study at 40 POTWs that operated with at least secondary treatment to determine the fate and occurrence of the 129 priority pollutants. At each POTW an intensive week-long sampling program was conducted at appropriate sampling points, including at a minimum the POTW influent, secondary effluent, primary sludge, and secondary sludge (unless combined). The 40 POTWs were distributed according to size, location, treatment process(es) utilized, and percent industrial flow, to profile all POTWs with flows over 5 mgd that would be required to implement pretreatment programs. All but 1 of the 40 plants received over 5 mgd; the exception was a POTW that employed rotating biological contactors. It was chosen to include that unit operation. Two POTWs with virtually no industrial flow were included to observe baseline conditions, while the other 38 POTWs had industrial flows ranging from approximately 4 to 50% of total flow. Normally, samples were collected for six 24-hour periods at each POTW. The results of the full study have not yet been published by EPA but some preliminary results pertinent to the RIA are presented in the following pages (Feiler 1980, Southworth 1981).

OCCURRENCE OF TOXIC POLLUTANTS

Over 100 of the 129 priority pollutants were detected once or more in POTW influents during the 40 POTW Study, although most were present in only a small percentage of the samples. The pollutants that were detected in more than 50% of influent samples (and their average concentration) are listed below.

Metals

Zinc (719 g/liter)
Copper (224 g/liter)
Lead (98 g/liter)
Chromium (174 g/liter)

Organics

Toluene (214 g/liter)
Benzene (20 g/liter)
Tetrachloroethylene (125 g/liter)
Trichloroethylene (76 g/liter)

Cyanide (544 g/liter)
Nickel (118 g/liter)
Cadmium (38 g/liter)
Silver (9 g/liter)
Mercury (550 g/liter)
Ethylbenzene (18 g/liter)
1,2-Trans-Dichloroethylene (7 g/liter)
Di-N-Butyl Phthalate (9 g/liter)

Chloroform (16 g/liter)
Methylene (515 g/liter
Bis(2-ethylhexyl)phathalate (45 g/liter)
1,1,1-Trichloroethane (223 g/liter)
Phenol (53 g/liter)
Butyl Benzyl Phthalate (11 g/liter)
Diethyl Phthalate (4 g/liter)
Naphthalene (7 g/liter)

In general, the pollutants in the influent were the same as those detected in the effluent. However, some of the common volatile organic pollutants were detected less frequently in sludges than in POTW influents.

PASSTHROUGH OF TOXIC POLLUTANTS

POTWs were found to remove a varying degree of priority and conventional pollutants. Table B4-I presents the median removal and passthrough for individual metal priority pollutants and for the other major classes of compounds. No data were available for beryllium, selenium, thallium, and pesticides because all were detected too infrequently in POTW influents. The following were the major trends observed in an analysis of these data.

- Of the metals, nickel had the greatest passthrough in terms of percentage (68% pass through).
- Copper and zinc were the metals best removed by POTWs (82% and 75% removal respectively).
- Toxic organics were also removed by POTWs. Volatile organics (which predominate among the total organics) were reduced by 81% at the median plant, with 19% subsequently passing through to the secondary effluent.

ACCUMULATION OF TOXIC POLLUTANTS IN POTW SLUDGE

Virtually all of the metal priority pollutants removed by the POTW accumulated in the resulting sludge streams. The concentration factors (defined as sludge concentration divided by influent concentration) in both

TABLE B4-I

MEDIAN REMOVALS AND PASSTHROUGH OF PRIORITY POLLUTANT IN POTWs

	Secondary Treatment		Advanced Wastewater Treatment*	
Pollutant	Median Percent Removal	Median Passthrough	Median Percent Removal from Secondary Effluent	Median Passthrough
Metals				
Antimony	56%	44%	ID	--
Arsenic	50	50	ID	--
Cadmium	50	50	ID	--
Chromium	70	30	26	74
Copper	82	18	0	100
Cyanide	59	41	0	100
Lead	57	43	0	100
Mercury	51	49	25	75
Nickel	32	68	11	89
Silver	70	30	ID	--
Zinc	75	25	14	86
Volatiles	81	19	33	67
Acid Extracts	97	3	25	75
Base-Neutral	64	36	0	100
Conventionals				
BOD	90	10	62	38
TSS	91	9	41	59
COD	81	19	17	83
Oil & Grease	84	16	15	85
Total Phenols	73	27	63	37

ID = insufficient data

*Based on seven plants with a variety of treatment primary, secondary, and combined sludges varied greatly. Depending on the solids content and other factors, but usually ranged from 10 to 1,000. Volatile priority pollutants that were present frequently and that were sufficiently above their detection limits generally had concentration factors between <1 and 10. The nonvolatile organic priority pollutants had concentration factors between the two other groups.

Several priority pollutants that were found to be below their detection limits in most POTW influents regularly were quantified in sludge streams. Pollutants with this tendency included antimony, arsenic, silver, selenium, phenanthracene/anthracene, and pyrene. For example, arsenic was measured above its detection limit in only 15% of all influent samples, but in 94% of all sludge streams.

Effect of Industrial Contribution on Priority Pollutant Occurrence

Table B4-II presents data showing the effect of industrial flow to POTWs influent concentrations for specific priority pollutants. Two sources of data were used as baseline priority pollutant concentrations:

- The average of two plants from the POTW data base that had little industrial flow (plants No. 2 and 9).
- The average of the projected residential and commercial loading from the EPA study of four cities. These represent samples from specific interceptors that contained no industrial flow.

The comparative data used are the overall influent averages from the 40 POTW study, which included most of the categorical industries within contributors to the POTWs. For many of the volatile organic pollutants the baseline data were an order of magnitude or more lower than the 40 plant average. The trend extended to the metals and nonvolatile organic pollutants, although the percentage differences were smaller. Most of the toxic metals were 2 to 6 times higher on the average for POTWs that received industrial influent than in the cases where there were no industrial contributors.

TABLE B4-II

EFFECT OF INDUSTRIAL FLOW ON SPECIFIC PRIORITY POLLUTANTS

Pollutant	40 POTW Study Avg. 2 Plants with Low Industrial Flow	EPA 4 City Study Avg. Residential and Commercial*	40 POTW Study Avg. All Plants
Cadmium	4	1	39
Chromium	63	37	175
Copper	62	59	225
Cyanide	80	1	574
Lead	54	43	99
Nickel	34	8	119
Silver	6	3	9
Zinc	219	130	718
1,2-Dichloroethane	1	0.1	585
Methylene Chloride	7	NR	516
1,1,1-Trichloroethane	<5	3	223
Toluene	7	6	218
Tetrachloroethylene	5	14	127
Trichloroethylene	18	7	77
Vinyl Chloride	<5	NR	46
Ethylbenzene	2	2	22
Methyl Chloride	1	NR	21
Benzene	6	1	21
Chloroform	5	5	17
1,2-Dichloroproprane	<5	NR	11
Phenol	3	5	55
Bis(2-Ethylhexyl) Phthalate	8	5	45
Pentachlorophenol	1	4	13
Butyl Benzyl Phthalate	<20	8	12

NR = not reported

All units are ug/l

*Adams et al 1981

Effect of a Pretreatment Program on POTW Influent and Effluent Quality

The data from the 40 POTW study were examined to determine whether there were any differences in influent and effluent quality between cities that had exemplary pretreatment programs at the time of sampling and cities that had not yet developed their pretreatment programs. The classification of the pretreatment programs were largely subjective and judgmental, based on factors such as completion of detailed industrial waste survey, sampling, analysis, flow measurement and regulation of industrial discharges, publication of a comprehensive ordinance, maintenance of facilities, and personnel exclusively devoted to industrial waste. Nine of the 40 POTWs were judged to have such a program. These nine POTWs had between 7 and 44% industrial flows with a median of 16%. For comparison, the remaining 31 plants had a median industrial flow of 18% and a range of 1-50%.

Table B4-III shows the average concentration for each priority pollutant fraction. The influent from plants with pretreatment programs is lower than plants without pretreatment for all classes of priority pollutants although the trend does not extend to each pollutant. For example, total priority pollutant metals were 28% higher in the influents of POTWs without pretreatment programs than in POTWs with programs; acid base neutrals were 76% higher and volatiles were 315% higher in the POTWs without pretreatment.

Effect of Toxic Pollutant Concentration in Influent on Removal of Toxic Pollutants

Preliminary data from the 40 POTW study indicate that removal of any particular toxic pollutant is not affected to any degree by the influent concentration of that pollutant. At this time, regression analysis has been performed for only the most commonly occurring metal and volatile priority pollutants, and the data indicate that removal for each is almost completely independent of influent concentration. The significance of this analysis is that added concentrations of toxic pollutants contributed by industry will only be removed by the POTW at its normal removal rates. Removal effiency will not increase or decrease as influent concentration increases. However, at very high concentrations of priority pollutants (higher than those encountered in the 40 POTW study) interference with the POTW can occur, reducing both conventional and toxic removal efficiency.

TABLE 34-III

EFFECTS OF PRETREATMENT PROGRAM ON INFLUENT CONCENTRATION OF SPECIFIC PRIORITY POLLUTANTS

	Influent (µg/liter)		Effluent (µg/liter)	
Pollutant	Plants with Programs	Plants without Programs	Plants with Programs	Plants without Programs
Cadmium	25	40	2	3
Chromium	147	179	24	36
Copper	237	222	41	38
Cyanide	565	579	142	169
Lead	53	112	7	17
Nickel	82	129	68	62
Silver	10	8	1	1
Zinc	470	786	92	186
Total of all Metals	1607	2057	383	514
1,2 Dichloroethane	N-D	718	0	194
Methylene Chloride	148	597	86	430
1,1,1 Trichloroethane	43	264	10	32
Toluene	132	236	6	12
Tetrachloroethylene	31	147	12	21
Trichloroethylene	74	75	8	6
Vinyl Chloride	2	56	0	3
Ethyl Benzene	20	21	1	0
Methyl Chloride	5	24	44	5
Benzene	25	18	0	1
Chloroform	9	17	6	6
1,2 Dichloropropane	N-D	13	0	0
Total of all Volatiles	534	2216	178	711
Phenol	42	56	0	1
Bis (2-Ethylhexyl)Phthalate	47	43	21	21
Pentachlorophenol	1	15	0	8
Butyl Benzyl Phthalate	5	12	0	0
Total of all Acid Base Neutrals	107	188	22	35

B-5. CASE STUDIES OF POTW OPERATIONS

SUMMARY

A limited number of POTWs were examined to determine and assess differences in POTW operating parameters before and after industrial waste pretreatment processes were initiated. The POTWs were analyzed to determine the effect of pretreatment programs on elminating or reducing environmental problems, and to determine the motivation involved in addressing industrial waste control. The municipalities were selected because descriptions of their industrial waste control programs have been published in the available literature. The municipalities represent a variety of population sizes, service areas, waste flows, and types and quantities of industrial flows. Some of the POTWs that were evaluated intiated control programs as early as 1961, but most programs were started in 1969-1970. Two of the POTWs started their programs in 1978. The types of industrial users covered in this analysis include:

- Chemical Manufacturers
- Commercial Laundries
- Dairies
- Electroplaters
- Fabricated metal Manufacturers
- Food Processors
- Petroleum Refineries
- Steel Mills
- Textile Manufacturers

The general conclusion drawn from this analysis is that percentage reductions of pollutants improve with pretreatment program implementation.

Most of the POTWs adopted their local pretreatment programs prior to the publication of the General Pretreatment Regulations of 1978. The generic

reasons these POTWs gave for controlling industrial flows into their treatment plants are:

- To improve sludge treatment, handling, and disposal practices
- To improve water quality
- To protect POTW systems and operations.

Of the POTWs that stated reasons, 14% cited sludge disposal problems, 43% cited water quality problems, and 43% cited POTW protection. In addition, one POTW developed its local program in order to accommodate a new industry that planned to locate in the area.

DESCRIPTION

The available information for several POTWs was examined and analyzed to assess differences in POTW operating parameters before and after industrial waste pretreatment programs. Information sources included academic and trade literature, published reports by POTWs and EPA, and JRB's telephone survey of nine POTWs. Responses to the telephone survey are provided at the end of this Appendix. In all, 19 municipalities were examined in detail as case studies; of these, 8 were found to have sufficient documentation on pretreatment to be included in this Appendix. Table B5-I provides an overview of the characteristics of the municipal treatment facilities included herein.

The purpose of this analysis was to determine the effect of industrial pretreatment on POTW pollutant removal efficiencies. While some of the literature and published reports provide data specifically suited to this purpose, many only provide descriptive information on how the local pretreatment program was established, and what lessons were learned. As a result, the sample size for the removal efficiences of some pollutants is quite small.

Telephone surveys of nine POTWs were used to improve the sample size. A followup form was sent to the POTWs (see Figure B5-1).

TABLE B5-1

OVERVIEW OF POTWS EXAMINED AS CASE STUDIES

Muncipality	Average Daily Flow (MGD)	Percentage Industrial Flow	Major Industries
Muncie, Indiana	18	33%	Foundries, Metal Platers, Manufacturers of Automative Parts
Los Angeles Country, California	469	18%	Petroleum Refining, Fabricated Metals, Paper, Food Chemicals
Grand Rapids Michigan	49	ND	Electroplaters
Oakland, California	79	17%	Pigment Manufacturing, Organic Chemical Refining, Petroluem Products Processing, Metal Plating, Food Processing
Chicago, Illinois	1,500	ND	Metal Platers, Steel Mills
Greensboro, North Carolina	26	17%	Textile Manufacturers, Cigarette Manufacturers, Meat Pakcers, Dairies, Food Processors, Metal Platers, Chemical Manufacturers
Champaign, Illinois	ND	3%	Food Processors
Orange Country, California	213	20%	Electroplaters, Printed Circuit Manufacteres, Battery Manufacturer's Paper Printing Industries

ND = No Data

Pollutant	Units	Influents		Effluents		Sludge	
		Before($^{\text{Year}}$)	After($^{\text{Year}}$)	Before($^{\text{Year}}$)	After($^{\text{Year}}$)	Before($^{\text{Year}}$)	After($^{\text{Year}}$)
BOD							
TSS							
Phenols							
Fat, Oil, and Grease (FOG)							
Metals:							
Arsenic							
Cadmium							
Chromium							
Copper							
Lead							
Mercury							
Nickel							
Zinc							
Cyanide							
Toxic Organics:							
Chlorinated Organics							
Pesticides							
Herbicides							
Flow							
Volume							

FIGURE B5-1

FORM USED IN THE TELEPHONE SURVEY
TO COLLECT DATA FROM POTWs

CHARACTERISTICS OF POTWS SELECTED AS CASE STUDIES

POTWs selected for case studies were chosen because the municipalities were representative of a variety of population sizes and service areas, average daily flows, types of industries, and quantities of industrial flow. Several POTWs initiated industrial pretreatment programs for conventional pollutants as early as 1961, but most initiated programs for conventional, toxic, and/or heavy metal pollutants in 1969 and 1970. Two POTWs started their programs as late as 1978. The sources of industrial waste discharged to the POTWs in the case studies include:

- Chemical manufacturers
- Commerical laundries
- Dairies
- Electroplaters
- Fabricated metal manufacturers
- Food processors
- Petroleum refineries
- Steel mills
- Textile manufacturers

SUMMARY OF FINDINGS FROM THE CASE STUDIES

To determine the effectiveness of industrial pretreatment programs in terms of removal efficiencies of specific pollutants, influent, effluent, and sludge concentrations were analyzed before and after program implementation. The results of this analysis are presented in Table B5-II. The general trend for the group of pollutants is toward improved removal efficiences after pretreatment program implementation. The most consistent percent reduction appears to be for influent metal values; for the group of eight metals, the case studiees indicate a 43% reduction has been achieved. Table B5-II suggests that higher removal efficiencies can be obtained at lower influent concentrations; presumably, a greater percentage of the metals are adsorbed onto the sludges. However, at least one POTW in the case studies implemented new and additional treatment operations at the same time as industrial control programs were implemented. Therefore, it is sufficient to say that the general trend is toward improved removal efficiencies when past influent values are compared to recent values.

TABLE B5-11

PERCENT REDUCTION IN POLLUTANT VALUES AFTER IMPLEMENTATION OF PRETREATMENT PROGRAM FOR VARIOUS POTWS FROM CASE STUDIES

	Percent Reduction in Influent Values			Percent Reduction in Effluent Values			Percent Reduction in Sludge Values		
Pollutants	N	Mean	Median	N	Mean	Median	N	Mean	Median
BOD	4	(4)	(2)	3	29	92	1	(6)	(6)
TSS	3	1	24	3	39	54	1	(8)	(8)
Phenols	3	(127)	(200)	2	19	19	0	ND	ND
Fats, Oils and Grease	2	20	20	2	51	51	0	ND	ND
Metals:									
Arsenic	3	47	33	2	66	66		ND	ND
Cadmium	5	13	14	3	53	50	3	20	60
Chromium	7	53	49	5	62	96	4	74	76
Copper	7	39	37	5	(56)	76	4	51	60
Mercury	3	50	32	2	65	65	0	ND	ND
Nickel	7	34	40	5	28	64	4	75	58
Lead	5	43	45	3	74	81	4	71	71
Zinc	7	53	51	5	64	60	64	51	55
Cyanide	5	(14)	71	4	(30)	(46)	0	ND	ND
Toxic Organics	2	94	94	1	99	99	0	ND	ND

ND = No Data

In all case study municipalities, one of two types of pollutant limitations has been established in industrial wastewater permits: concentration limits or mass emission limits. Because selection of limitation criteria is based upon local situations and POTW operational parameters, the use of either type of limitation is fully addressed in the discussion of each municipal program.

Municipalities gave one of three generic reasons for adopting local programs: 43% cited the improvement of water quality; 43% cited the reduction of POTW treatment costs; and 14% cited the improvement of sludge treatment, hauling, and disposal practices.

SPECIFIC POTW INDUSTRIAL PRETREATMENT PROGRAMS

Muncie, Indiana

Muncie's POTW recieves a fairly large industrial input; wastewater from about 80 industries contributes about one-third of its 18 MGD flow. Industries such as foundries, metal platers, and manufacturers of batteries, wire and transformers, and automotive parts produce most of the metal, oil, and acid wastes that were once major problems for the city. In recent years, the industrial discharges have been brought almost fully under control as a result of pretreatment limitations and industrial investment in pretreatment equipment.

Muncie established local ordinances for pretreatment limits on industrial wastes in 1972. Industries that discharge organic wastes to the POTW must pay a user charge for BOD loading greater than 250 mg/liter. The system in Muncie now generates about $125,000 in revenue per year from nine industrial users. Although no charges are assessed for toxic discharges, industries must meet the required pretreatment limits under reasonable time schedules. Figure B5-2 illustrates the success that the pretreatment program has had in limiting pollutant concentrations entering the POTW (USEPA, 1980a).

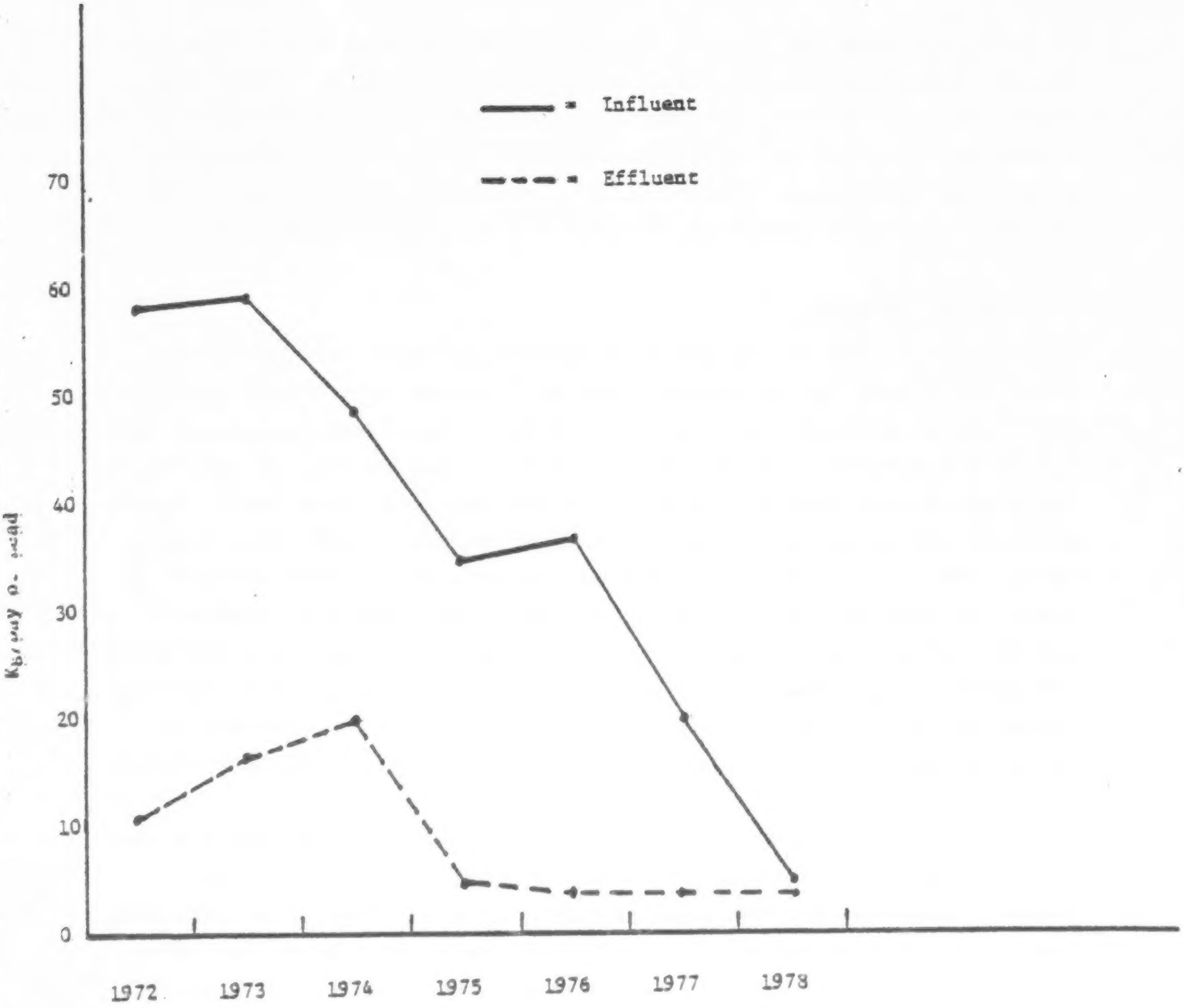


Figure B5-2. Industrial Loading of Lead into the Muncie, Indiana POTW, 1972-1978

Los Angeles County, California

The county sanitation districts of Los Angeles receive in flow of about 469 MGD, and about 85 MGD is from industrial sources. Table B5-III provides a breakdown of the principal industrial wastewater sources to the municipal plants. In 1980 the plants received a total of 30,925 million gallons of industrial waste.

Institution of the district's industrial wastewater control program brought significant improvements to effluent quality. Table B5-IV provides before and after influent pollutant values for the sanitation districts of Los Angeles County. Over the 5-years during which this industrial pretreatment program was implemented, heavy metals and toxic organics pollutants to the treatment plant were reduced by 44% and 98% respectively (Kremer, 1981).

Grand Rapids, Michigan

During the late fifties and early sixties, excessive industrial discharges of cyanide and heavy metals from metal platers were causing severe water quality deterioration of the Grand River. Grand Rapids has one of the largest concentrations of electroplating firms in the country, and fish kills in the Grand River were attributed to the effluents from these firms. Public attention was focused on the deterioration of the once healthy Grand River, and in 1969 the city adopted a sewer use ordinance establishing effluent limits for heavy metals and cyanide. Effluent limits were also established for BOD (300 mg/liter), suspended solids (350 mg/liter), fats, oil, and grease (50 mg/liter), and phenols (0.02 mg/liter). A cost recovery system requiring industrial users to pay proportionate shares of the cost for effluents in excess of the limits for BOD and suspended solids was a part of the ordinance.

Table B5-V and Figures B5-3 and B5-4 illustrate the effectiveness of the Grand Rapids industrial waste pretreatment program for heavy metals and cyanide, respectively. Most significantly are the reduction in influent concentrations shown on Table 5-V. For the heavy metals as a group, the reductions for influent and effluent concentrations are 87% and 92% respectively. The results shown on Figures B5-3 and B5-4 suggest that higher removal efficiencies can be obtained at lower influent concentrations, with a greater

TABLE B5-III

PRINCIPAL INDUSTRIAL SOURCES OF WASTEWATER RECEIVED BY LOS ANGELES COUNTY SANITATION DISTRICTS

Industry	Average Flow (MGD)	Percent of Industrial Flow	Percent of District Flow	Number of Companies
Petroleum Refining & Related Industries	14.0	16.5	3.0	27
Fabricated Metal Products	9.7	11.4	2.1	419
Paper and Allied Products	9.4	11.1	2.0	46
Food and Kindred Products	9.2	10.9	2.0	208
Chemicals and Allied Products	5.1	6.0	1.1	172

Source: Kremer, 1981

TABLE B5-IV

INFLUENT POLLUTANT VALUES BEFORE AND AFTER INDUSTRIAL PRETREATMENT PROGRAM, LOS ANGELES COUNTY, CALIFORNIA

Pollutant	Influent (kg/day) Before (1975)	Influent (kg/day) After (1980)	Percent Reduction
Phenols[1]	4626	3200	30
Arsenic[2]	34	6.8	80
Cadmium	50	36.3	27
Chromium	952	635	33
Copper[3]	680	408	40
Mercury	1.36	0.91	33
Nickel	408	295	28
Lead	454	227	50
Zinc	2494	1224	51
Cyanide	590	194	73
PCB	29	0.91	97
DDT & Metabolic Products	295	0.91	>99

[1] This pollutant, which is essentially discharged only by industrial sources, was a candidate for source control limits. However, a reduction in the 4,626 kg/day discharge was not required to meet effluent discharge requirements, so no limits were adopted. Phenols are discharged mainly by petroleum refining and allied companies. The decrease in phenol discharges is related to decrease in gasoline production.

[2] It is estimated that only abut 1.6kg/day of the decrease is attributable to the district's source control program. Most of the decrease has been due to changes in formulations of household pesticides and action by State of California and OSHA.

[3] While the districts instituted a source control limit for mercury, all available information shows there are no significant industrial discharges of mercury to district sewer systems. The observed decrease is similar in percentage magnitude to that observed at the district's residential treatment plant. Therefore, factors other than the district's source control program account for the apparent 33% reduction.

Source: Kremer, 1981

TABLE B-5-V.

EFFECT OF SEWER USE ORDINANCE ON INFLUENT AND EFFLUENT CONCENTRATION, 1968 to 1977, GRAND RAPIDS, MICHIGAN

Pollutant	Influent % Reduction	Effluent % Reduction
Chromium	90	96
Copper	89	93
Nickel	87	89
Zinc	79	85
Cyanide	93	96

Source: Biemer & Bouma, 1978b

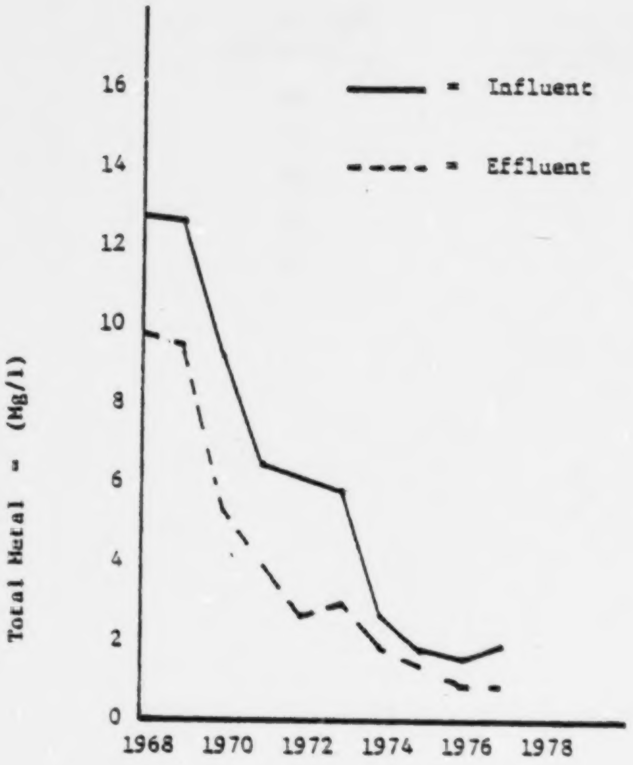


Figure B5-3. Total Metals Influent and Effluent Concentrations, 1968-1977

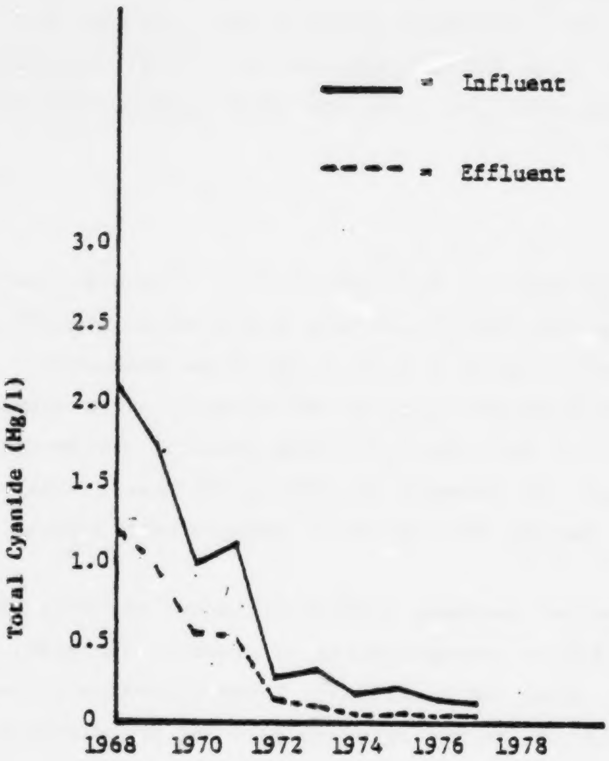


Figure B5-4. Cyanide Influent and Effluent Concentrations, 1968-1977

percentage of the heavy metals adsorbed onto the sludges. Neufeld (1975) confirms these findings in tests with zinc and particularly cadmium using biological sludges. The 40 POTW Study (Feiler 1980 and Southworth 1981) indicates percent removal to be independent of concentration found in POTW influents.

The most significant direct benefit from the sewer use ordinance has been the improvement in water quality of the Grand River. By 1974 steelhead trout and Coho and Chinook salmon were sprawning in the river. The city has purchased parkland along the river for recreational activities, and has now constructed and improved boat ramps for canoe and other boating enthusiasts (Biener & Bouma, 1978a & b).

Oakland, California

In the late sixties, the East Bay Municipal Utility District, headquartered in Oakland, California, determined that a wastewater control program was needed for POTW effluents to achieve Federal and State standards. Industrial discharges received in the District are primarily from pigment manufacturing, organic chemical refining, petroleum products processing, metal plating, and food processing. In December of 1972, a wastewater control ordinance was adopted that created the District's pretreatment program.

The results of this new pretreatment program are shown on Table B5-VI. As indicated, much lower influent concentrations of arsenic, chromium, copper, lead, mercury and zinc were noted and accordingly lower discharge concentrations, see Table B5-VII. Removal percentages are good but not directly comparable before and after because in addition to the pretreatment program, secondary treatment was implemented during this period (Damas, 1981).

Chicago, Illinois

The Metropolitan Sanitary District of Greater Chicago operates and maintains six plants that treat a flow of approximately 1,500 MGD. Metropolitan Chicago has the nation's largest industrial concentration. There

TABLE B5-VI

HEAVY METAL INFLUENTS BEFORE AND AFTER PRETREATMENT PROGRAM OAKLAND, CALIFORNIA

Pollutants	Past Values (kg/day)	Recent Values (kg/day)	Percent Reduction
Arsenic	<3	<1	67
Cadmium	7	6	14
Chromium	209	45	78
Copper	318	54	83
Lead	106	51	52
Mercury	95	.5	>99
Nickel	35	35	0
Zinc	495	263	71

Source: Damas, 1981

TABLE B5-VII

POTW EFFLUENT PAST AND RECENT QUALITY VALUES FOR HEAVY METALS, OAKLAND, CALIFORNIA

Pollutants	Past Values (kg/day)	Recent Values (kg/day)	Percent Reduction
Arsenic	<3.0	<1.0	67
Cadmium	4.0	0.6	85
Chromium	175.0	7.4	96
Copper	129.0	30.0	77
Lead	60.0	4.6	92
Mercury	4.0	<0.1	>98
Nickel	37.0	30.0	19
Zinc	385.0	46	88

Source: Damas, 1981

are about 11,000 industries in the 865 square mile district, over 500 metals platers are included in this total.

In September of 1969, a Sewage and Waste Control Ordinance was adopted. The purpose of the ordinance was to

- Ensure that the effluents from the six POTWs would meet new discharge standards imposed by the state
- Protect the treatment plants from upsets
- To allow industry ample latitude regarding the type of pretreatment systems needed to control discharges to the sewer system.

The ordinance sets specific concentration limits for pollutants and limits conditions for the discharge of wastes to the sewage system. The controlled discharge of these pollutants is considered necessary to ensure occupational safety; to protect the physical, chemical, and biological integrity of the system; and to allow the sludge produced by the plants to be used as a fertilizer for land reclamation.

The effectiveness of the program is evidenced by the reductions in metal loadings to the District's plants. Figure B5-5 provides a 7-year profile of heavy metal loadings. A 70% reduction in these metals was reported for 1977 compared to 1971. Table B5-VIII provides the percent reductions of specific metal influents to the plants from 1971 to 1977 (Lue-Hing, 1981).

Greensboro, North Carolina

Greensboro operates one POTW that receives 8 MGD and one that receives 18 MGD; 17% of the flow, 28% of the suspended solids, and 49% of the BOD volume of industrial waste water. Textile manufacturers account for the largest volume of industrial waste water. Other local industries include cigarette manufacturers, meat packers, dairies, food processors, metal platers, and chemical manufacturers.

The waste ordinance adopted in Greensboro established limits for copper, zinc, chromium, and cyanide. No limits for BOD or suspended solids were adopted, but these pollutants are subject to a surcharge.

Figure B5-5. Heavy Metal Loading to Six POTWs, Chicago, Illinois

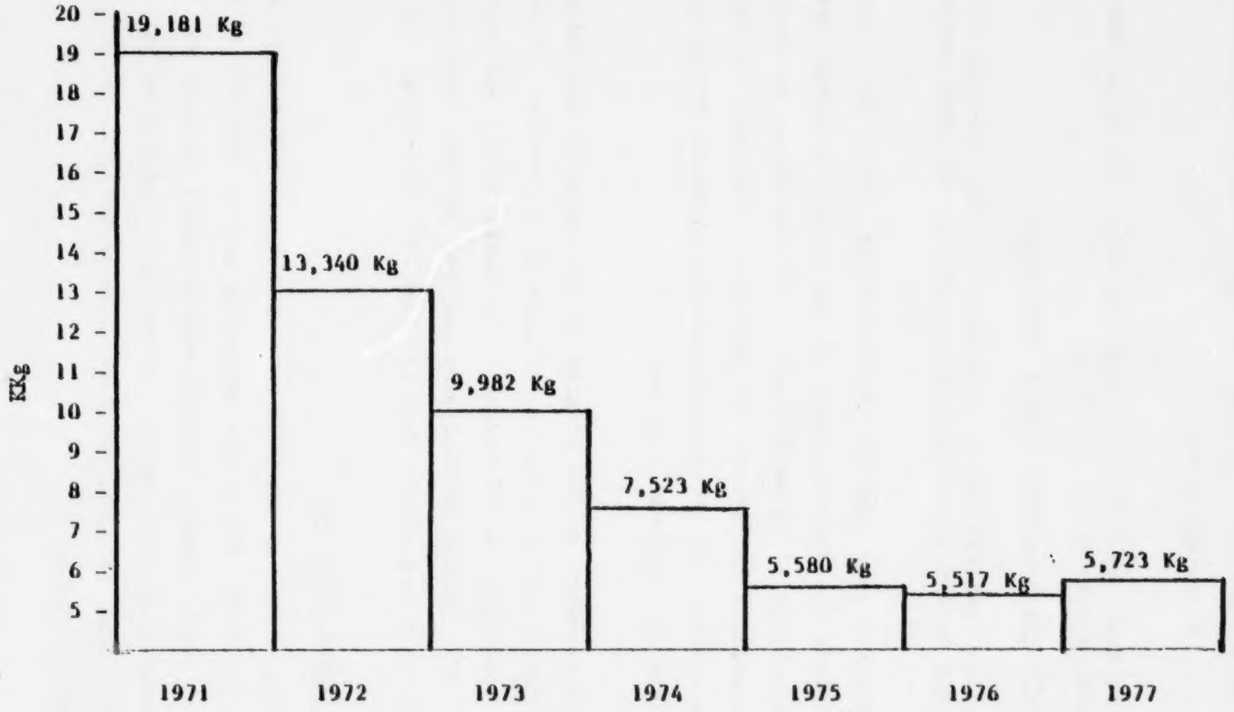


TABLE B5-VIII

METAL REDUCTION IN PLANT INFLUENT, CHICAGO, ILLINOIS

Pollutants	Past Values (kg/day)	Recent Values (kg/day)	Percent Reduction
Cadmium	397	168	58
Chromium	5,185	1,419	73
Copper	2,161	586	73
Lead	2,044	535	74
Nickel	2,437	434	82
Zinc	6,956	2,581	63

Source: Lue-Hing, 1981

Two specific improvements in industrial effluent pollutant concentrations are noteworthy. A local poultry processing plant reduced both BOD and suspended solids by 66% by installing a blood trench to prevent waste from entering the sewer system. A slaughterhouse reduced BOD by 68% and suspended solids by 59% by improving process operations.

Greensboro has found its pretreatment program to be financially self-sustaining. Surcharges imposed upon industry add considerable income to the general revenue of the local water and sewer department. Industry is kept aware of the problems associated with the treatment of industrial waste and the related POTW costs. Waste loads to the POTW are lower than they would be without a control program, and information on both current and long-term waste strength and volume have permitted extended predictions of treatment plant life (Shaw, 1970)

Champaign, Illinois

In the late sixties, a major food processor in Champaign, Illinois, decided to expand plant size to increase production of margarine, salad dressings, and cheeses. Before accepting the additional load from the expanded plant, the municipality required the processor to meet the following limits contained in a proposed city ordinance:

- 200 mg/liter of BOD
- 200 mg/liter of suspended solids
- 100 mg/liter of fats, oils, and grease

In order to achieve the required effluent concentrations, the processor installed pretreatment equipment designed to handle a flow of 500,000 GPD. The effectiveness of the pretreatment equipment was evident in the percent removal of the three pollutants regulated by the municipality. Figure B5-6 provides this information for the first 7 months of operation. Values exceeding the limits prescribed by the municipality were noted during the first 3 months, but the concentrations fell to an acceptable level by the beginning of the fourth month. The high initial values were attributed to the startup problems associated with dewatering digested sludge. These problems

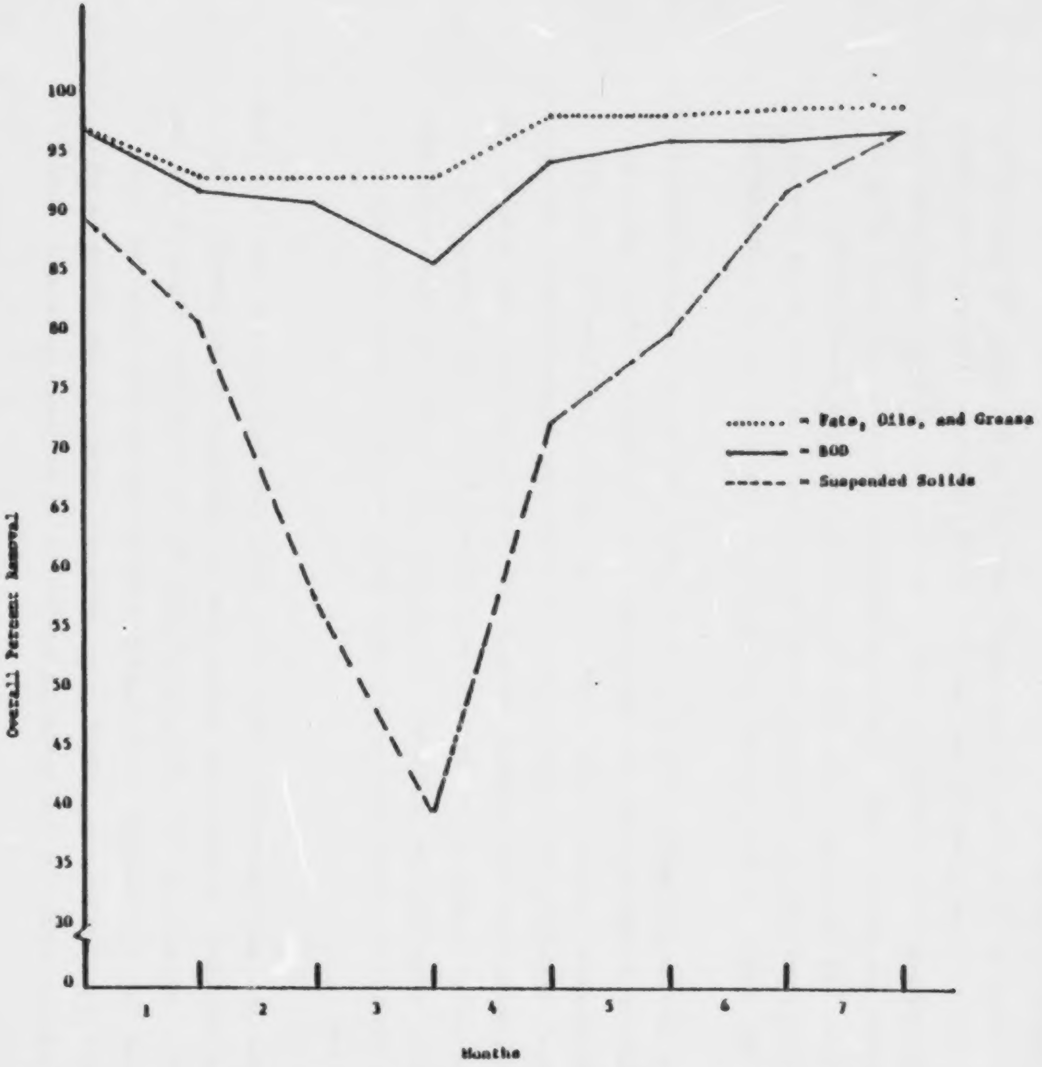


Figure B5-6. Pollutant Removal Efficiencies for First Seven Months of Operation Champaign, Illinois

were corrected, and the equipment has operated well since that time, with all pollutant removal efficiencies equal to or greater than 97%.

Figures B5-7, B5-8, B5-9 provide comparisons between raw waste and final effluent for BOD; suspended solids; and fats, oils, and grease, respectively.

Orange County, California

As early as 1954, the Orange County Sanitation District recognized the need to control the quantity and quality of wastewaters discharged to their sewerage systems. In subsequent years, the District adopted ordinances that established industrial waste discharge permits, provided for monitoring of discharges, and set limits for certain conventional and toxic wastes. The toxics ordinance was in response to the clean water legislation of the early 1970's and sought to meet stated environmental goals of the 1972 Amendments.

The ordinance represented a cooperative effort between the District, local industry representatives, and consulting engineers. While many local waste ordinances specify toxic concentration limits, the District and the industrial community decided that this approach was inappropriate. Concentration limits were not adopted because these criteria would not address the value of water conservation and the limitation of the total quantity of pollutants entering the treatment facilities. To respond to these considerations, industrial waste discharge limits were specified by average daily quantities.

Once the mass emission limits for specific pollutants and specific firms were established, industry was encouraged to implement water conservation measures. Because of the criteria adopted by the District, industry was not penalized for the changes in pollutant concentrations that resulted from conservation initiatives. Similarly, industry could not introduce large quantities of water to the sewerage system in an attempt to reduce concentration limits.

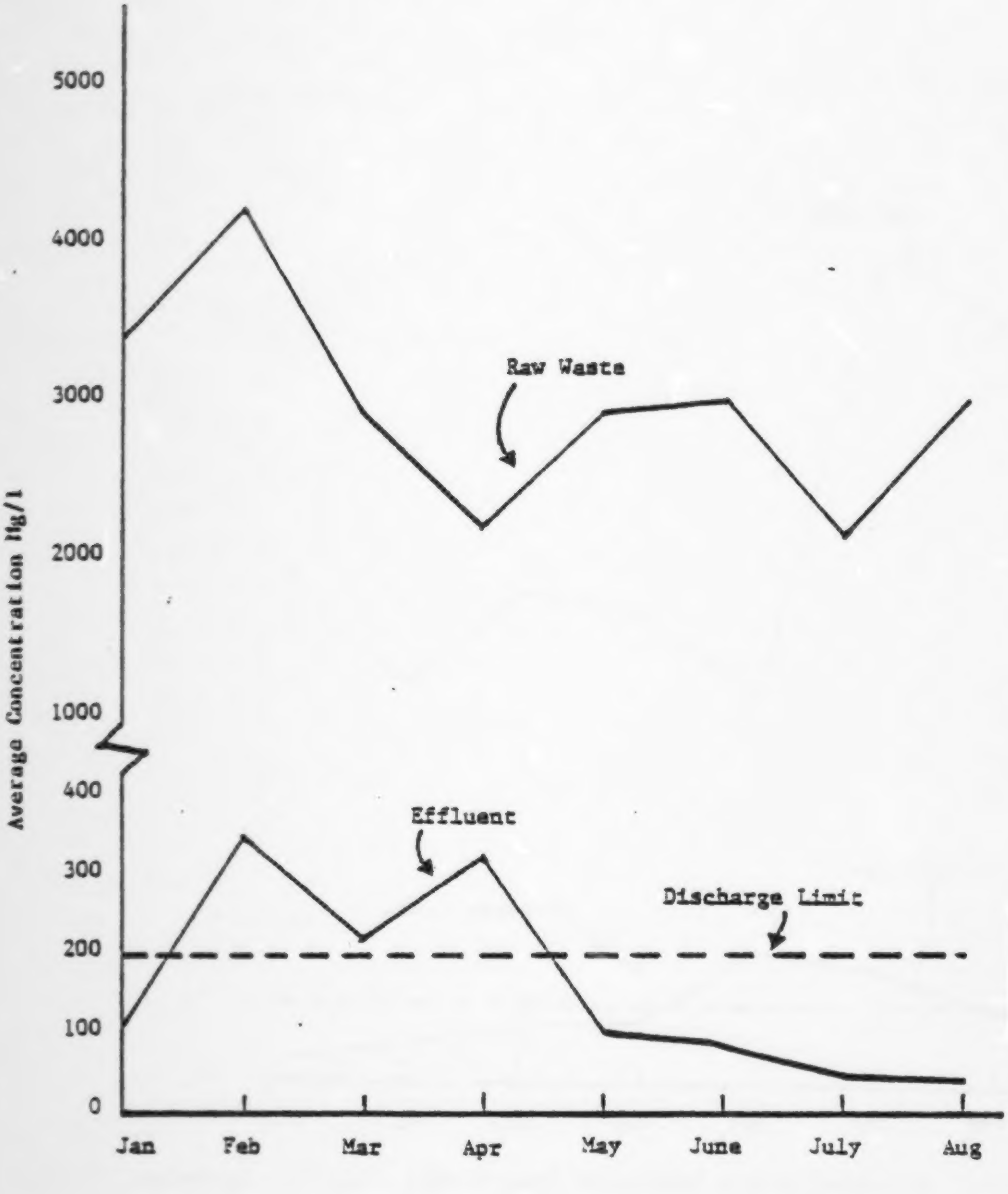


Figure B5-7. BOD Removal at Pretreatment Facility, Champaign, Illinois

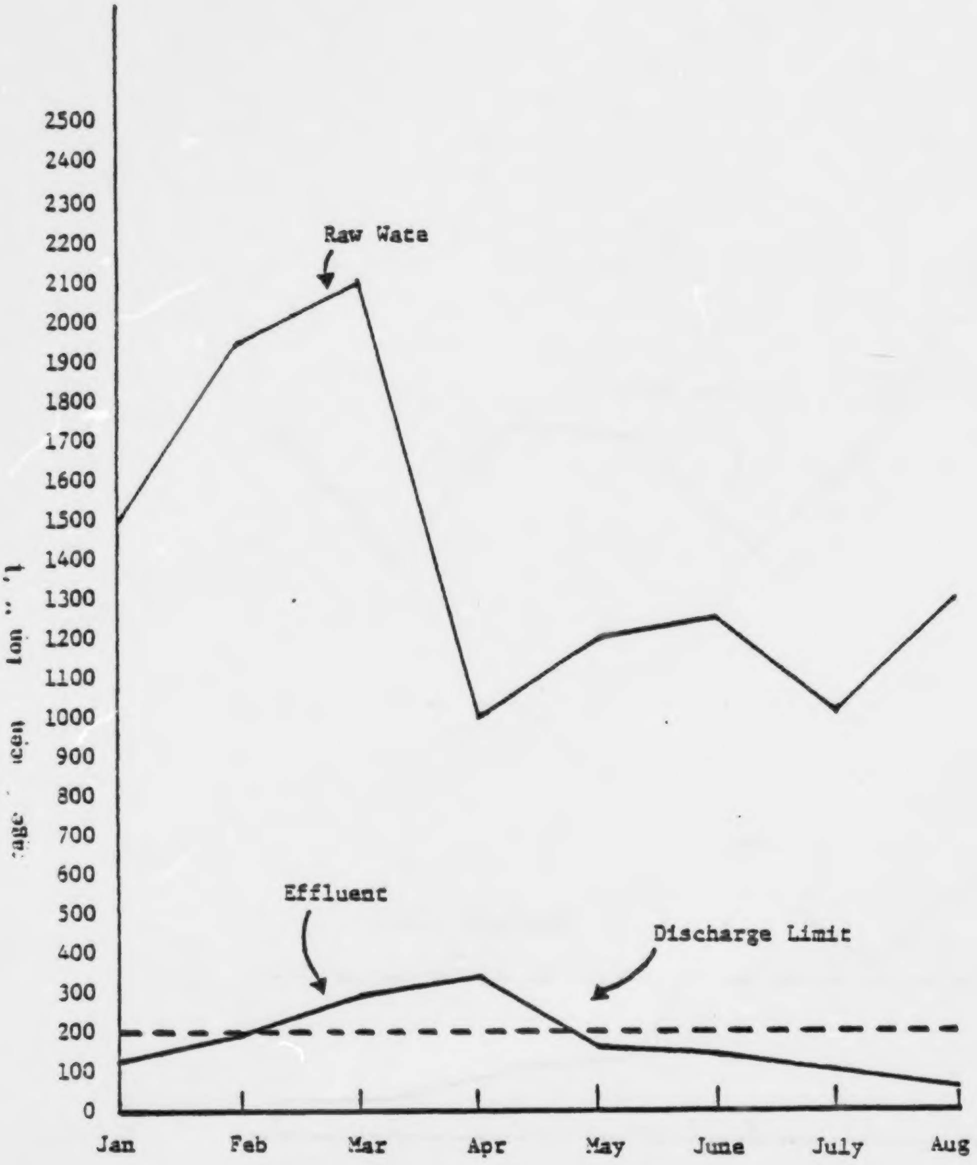


Figure B5-8. Suspended Solids Removal at Pretreatment Facility, Champaign, Illinois

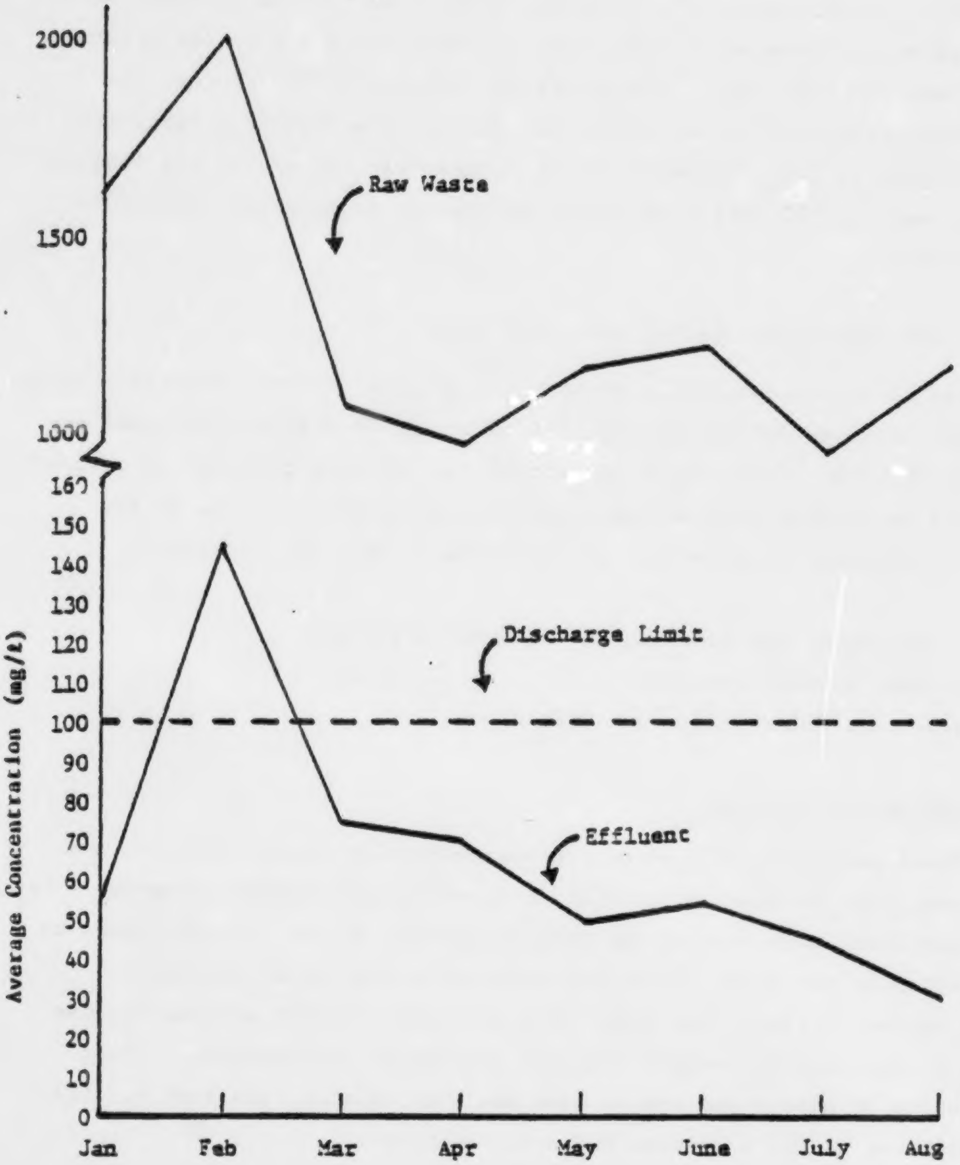


Figure B5-9. Removal of Fats, Oils, and Greases at Pretreatment Facility, Champaign, Illinois

The results of the control program have included reduced wastewater discharge volumes and pollutant quantities. Industry reduced water discharge to the sewerage system by 2.5 million and 3 million gallons per day during 1978 and 1979, respectively. In addition, a 46% reduction in influent metal loadings (cadmium, chromium, copper, lead, nickel, and zinc) to the treatment facilities was achieved over a 5-year period. Figure B5-10 provides the specific quantity reductions in metal influents to the treatment facilities over this 5-year period. Chromium and zinc have been reduced by the largest percentage; each is 55% less than levels before the program was implemented (Lewis, undated).

MOTIVATION FOR INDUSTRIAL PRETREATMENT PROGRAMS

A total of 14 municipalities in the case studies adopted industrial waste pretreatment programs before the publication of the General Pretreatment Regulations of 1978. Thus, their motivation for adopting programs is derived from reasons other than Federal requirements. Three generic reasons for adopting pretreatment programs are cited in the literature and reports:

- To improve sludge handling and disposal practices
- To improve water quality
- To protect POTW systems and operations.

Sludge Handling and Disposal

Two municipalities (14%) cited the improvement of sludge handling and disposal practices as their motivation in adopting pretreatment programs. One of these municipalities adopted the program because of the limited number of disposal sites in the state for sludge containing high metal and toxic pollutant concentrations. The other adopted a pretreatment program because its ocean sludge disposal permit required industrial pretreatment. Sludge concentrations of metals and toxics have now been reduced, and land application is employed as the preferred disposal technique.

Figure B5-10. Influent Pollutant Values,
Before and After Industrial Pretreatment Program,
Los Angeles County, California

Pollutant	Influent (Kg/d) Before (1975)	Influent (Kg/d) After (1980)	Percent Reduction
Phenols[1]	4626	3220	30
Arsenic[2]	34	6.8	80
Cadmium	50	36.3	27
Chromium	952	635	33
Copper[3]	680	408	40
Mercury	1.36	0.91	33
Nickel	408	295	28
Lead	454	227	50
Zinc	2494	1224	51
Cyanide	590	194	73
PCB	29	0.91	97
DDT & Metabolic Products	295	0.91	> 99

1. This pollutant, which is essentially discharged only by industrial sources, was a candidate for source control limits. However, the 4,626 Kg/day discharge was not required to be reduced to meet effluent discharge requirements, so no limits were adopted. Phenols are discharged mainly by petroleum refining and allied companies. The observed decrease in phenol discharges is related to decreases in gasoline production.

2. It is estimated that only about 1.6 Kg/day of the decrease is attributable to the districts' source control program. Most of the decrease has been due to changes in formulations of household pest poisons and action by State of California CAL/OSHA.

3. While the districts instituted a source control limit for mercury, all available information shows there are no significant industrial dischargers of mercury to districts' sewer system. The observed decrease shown is similar in percentage magnitude to that observed at the districts' residential treatment plant. Therefore, factors other than the districts' source control program account for the apparent thirty-three percent reduction.

Water Quality

Six municipalities (43%) cited the need to improve water quality as their motivation in adopting pretreatment programs. Several of these municipalities required industrial pretreatment in response to state plans for specific receiving waters. Three of the municipalities adopted programs in response to public reaction against fish kills, malodorous water in drainage canals, and general water quality deterioration.

POTW Protection

Six municipalities (43%) cited the need to protect the POTW operations and equipment from periodic, highly concentrated slugs from industrial sources.

B-6. SUMMARY - WORKER HEALTH AND SAFETY, AIR AND GROUNDWATER

A review of the potential impacts of industrial wastes in areas other than surface water quality was conducted. The three areas of concern covered in Section B-6 of this Appendix focus on Worker Health and Safety, Air, and Groundwater. The following conclusions are drawn from the studies presented in Section B-6:

WORKER HEALTH AND SAFETY

- Documented instances in which industrial wastes entering POTWs have caused health and safety hazards to wastewater treatment workers are found in the literature. Potential health and safety problems include exposure to toxic aerosols and fumes, and the danger of explosive gases and materials.
- The problems described in the case studies reviewed in this section were due to shock loads of toxic chemicals into the POTW, but evidence the potential problems that can exist under normal operation.
- The types of pollutants that can cause health and safety problems are present in POTW influent and are subject to pretreatment regulations. The potential for problems could be reduced with industrial pretreatment control.

AIR

- 1,067,432 tons of sludge are incinerated annually in the United States. This number is expected to increase in the next decade as landfill space becomes restricted.
- The possible sources of air pollution from incineration of sludge include particulate emissions containing heavy metals and organics, odorous compounds, gaseous and volatile organics, and biological aerosols. Particulate emissions and heavy metals are of greatest concern.
- Reduction in concentration of pollutants in sludge, which can be accomplished through pretreatment, reduces the extent of air pollution caused by incineration of municipal sludge. However, pretreatment can result in the generation of additional industrial sludge which is likely to contain toxic pollutants. Therefore, air pollution caused by incineration of industrial sludge may increase.

GROUND WATER

- Approximately 1.3 billion gallons/year of POTW influent exfiltrates from the POTW, much of it is believed to reach groundwater sources.
- A few case studies conclusively show ground water contamination from POTW exfiltration caused by broken pipes and migration/leakage from holding ponds.

B-6-1. WORKER HEALTH AND SAFETY

Approximately 53,000 sewer workers may be exposed to toxic substances from industrial effluents. Many of these substances can cause acute and chronic health effects. Chemical substances that are discharged from industrial sources to POTWs can become airborne in the collection and treatment systems. Contaminants that are a concern in wastewater treatment facilities include volatile organic chemicals, heavy metals, asphyxiants, and explosive materials. Approximately 2,000 wastewater treatment systems are affected by pretreatment regulations. In an annual survey of wastewater treatment workers conducted by the Water Pollution Control Federation, the mean number of employees at each of 1,299 wastewater treatment plants and collection systems surveyed was 21 (WPCF, 1981).

POTW workers can be exposed to airborne chemical hazards in several activities, including

- Sampling of wastewater
- Manning the control room of the treatment system (often the pumps that feed the waste treatment system are located in the basement of the control house)
- Inspecting the system on regular rounds
- Inspecting the piping and lift stations in the sewage collection system
- Performing general maintenance activities.

Additionally, there may be secondary health hazards from the following sources:

- Accumulation of sewer gases from blockages caused by industrial discharges
- Skin contact with chemicals carried by foam
- Handling of strong acids and bases used as pH control reagents for waste streams with variable pH.

Volatile organic compounds may be discharged to the public sewer from numerous commercial and industrial establishments. Although such compounds may be in solution in the discharged water, the compounds may volatilize in the sewer or in the treatment unit because the unit generally operates at a slightly elevated temperature. The concentrations of these compounds in industrial effluents can be lowered by pretreatment. If pretreatment regulations are instituted, the concentrations of these substances in the water and subsequently in the air should be reduced.

In a recent study of 40 POTW facilities, volatile organic compounds were measured in the influent. Table B6-1-I shows the average concentrations and detection frequencies of 11 compounds that are commonly found in POTW influent. Table B6-1-II lists the airborne concentrations of several of these volatile organic compounds measured either at the treatment plant or in the collection system. These concentrations were reported in the case studies described in the following sections. Table B6-1-II also shows the applicable exposure criteria, toxicologic characteristics, phsyical properties, and industrial sources of volatile organics commonly found in the influent of POTWs. The health effects described in the case studies can be expected to occur if workers are exposed to concentrations of chemicals greater than the threshold limit value (TLV). As shown in Table B6-1-II, the values actually measured did not exceed the TLV. However, it is important to note that greater concentrations of volatile organics than those measured must have been present to have caused the health effects observed and reported in the case studies.

Heavy metals such as lead, mercury, cadmium, chromium, and nickel from industrial sources, including electroplating and battery manufacture, are also contained in the wastewater that reaches the POTW. In the aeration basin of a typical sewage treatment plant, the heavy metals may be adsorbed onto particulate matter and emitted to the air as aerosols. These metal-containing aerosols can be inhaled by workers during POTW operations. However, the metal concentrations that have been measured near aeration basins of POTWs are much lower than the established TLVs or permissible exposure limits (PELs). Therefore, based on limited data, concentrations of heavy metals in the POTW

TABLE B6-1-I

VOLATILES WITH HIGHEST INFLUENT CONCENTRATIONS

Organic Compound	Average (in g/l)	Percent of Time Detected
Benzene	21	59.3
Chloroform	17	90.3
1,2-Dichloroethane	585	14.4
Methylchloride	21	13.1
Methylene Chloride	516	94.1
Perchloroethylene	127	94.9
Toluene	218	97.9
1,1,1-Trichloroethane	223	87.3
Trichloroethylene	77	92.4
Vinyl Chloride	46	7.2

Source: U.S. EPA 1980

TABLE B6-1-II

Volatile Organic Compound	(Concentrations (in ppm))			Health Effects			Physical Properties		
	Acutually Measured[1]	TLV[2]	PEL[3]	Local Acute	Systemic Acute	Chronic	VP[4]	BP	Industrial Use
benzene	--	10	1	Skin irritant	CNS depressant	carcinogen of blood-forming tissue	75 mm	176°F	Solvent, constituent of motor fuels
chloroform	--[5]	10	50		Liver damage CNS effects	has caused cancer in humans when administered at high doses	160 mm	142°F	Solvent in pharmaceutical manufacture
1-2,dichloroethane	--	10	5	Eye and respiratory irritant	Narcotic effects	--	62 mm	183°F	Solvent, antiknock compound
ethyl benzene	--[5]	100	100	Eyes, nose, throat, and skin irritant	--	--	7.1 mm	277°F	Solvent, antiknock compound
methyl chloride	--	100	100	--	CNS depressant	CNS effects	4.8 atm	-12°F	Extractant, solvent used in organic chemical manufacture
methlene chloride		50[6]	500	--	Narcotic	--	350 mm	104°F	Solvent
perchloroethylene	5	100	100	Mild eye, nose, and throat irritant	CNS depressant; may cause hepatic injury	--	14 mm	250°F	Solvent, dry cleaning
toluene	37	100	200	Eye, respiratory, and skin irritant	CNS depressant	--	22 mm	231°F	Feed for chemical production, solvents fuel constituent
1,1,1-trichloroethane	180	350	350	Eye and dermal irritant	Narcotic	--	100 mm	165°F	Industrial solvent
trichloroethylene	20	50[6]	100	Eye, nose, and throat irritant	CNS depressant	--	58 mm	188°F	Degreasing solvent

TABLE B6-1-II (Continued)

Volatile Organic Compound	(Concentrations (in ppm)			Health Effects			Physical Properties		
	Acutually Measured[1]	TLV[2]	PEL[3]	Local Acute	Systemic Acute	Chronic	VP[4]	BP	Industrial Use
vinyl chloride	--	5[6]	1	Skin irritant	CNS depressant	strong correlation with CNS, respiratory, hepatic, and lymphatic cancer in humans	2,600 mm	6.98°F	Used in the manufacture of polyvinylchloride, solvent, and chemical manufacturing intermediate

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[1] Source: NIOSH, Interim Reports 1 & 2, Health Hazards Reports, 1981, Unpublished

[2] Threshold Limit Values (TLV) "refer to airborn concentrations of substances and represent conditions under which it is believed that nearly all workers may be repeatedly exposed day after day without adverse effect. These values are 8-hour time-weighted exposure levels."

[3] Permissible Exposure Limits (PELs) are the OSHA standard for these compounds the values are 8-hour time-weighted averages.

[4] at 20 C mm Hg

[5] 100-800 ppb concentrations were measured above the aeration basin of a WWTP. Source: Personal conversation, Paul Wagner - EPA/HERL

[6] Proposed TLV

[7] at 25 C mm Hg

workplace air do not appear to be a major occupational health hazard. The toxicologic properties and exposure criteria for heavy metals commonly found in POTW influent are shown in Table B6-1-III.

Explosive gases are of concern because they may collect in pockets in the waste collection system and be ignited by static electricity, sparks from electrical utilities, and high temperature. As a recent example, the catalytic converter of an automobile ignited explosive gases in a manhole causing significant damage to the sewer system in Louisville, Kentucky.

The types of problems discussed above have been documented in the following four case studies. In each case, workers exposed to industrial chemicals suffered a variety of acute symptoms. The long-term chronic effects of these exposures are not known. As knowledge of chronic effects such as carcinogenesis, reproductive abnormalities, and chronic organ damage increases, a more comprehensive picture of the risks faced by POTW workers may develop.

CASE STUDY I

Elia, et al. (1980), conducted an epidemiology study of diseases among wastewater treatment plant workers at the North Wastewater Treatment Plant in Memphis, Tennessee. The investigators measured concentrations of chemical substances in the workplace air. The plant, which uses secondary treatment, receives the effluent from a plant that uses and produces several chlorinated intermediates in manufacturing flame retardants and pesticides.

While investigating disease caused by microorganisms, the researchers noted an irritating odor characteristic of chemical waste. Employees at the wastewater treatment plant who were exposed to these odors complained of a variety of acute symptoms, including the following:

- o respiratory distress
- o dizziness
- o headache
- o irritation of the eyes and upper respiratory tract
- o skin irritation.

TABLE B6-1-III

Metals	Concentrations (in mg/m^3)			Health Effects			Industrial Use
	Actually Measured	TLV	PEL	Local Acute	Systemic Acute	Chronic	
Cadmium	1.57×10^{-5}	0.05	dust: 0.2 fume: 0.1	Respiratory irritant	Respiratory injury, lung damage	Suspected carcinogen, kidney damage	Protective coating applied by electroplating
Chromium	3×10^{-5}	0.5	0.1	Tracheo-bronchial irritant	--	Carcinogen of lungs and nasal cavity (Hexavalent chromium form only)	Protective coating applied by electroplating
Copper	2.1×10^{-4}	0.1	fume: 0.1 dust: 1.0	Skin irritant	Respiratory irritant	--	Electrical industry, pesticides
Lead	6.1×10^{-4}	0.15	0.05	--	--	Kidney damage, CNS damage	Battery manufacture antiknock compound
Nickel	1×10^{-5}	1.0	1.0	Skin sensitizer.	--	Carcinogen of nasal cavity, lungs, paranasal sinus	Electroplating, metal working
Silver	--	0.01	0.01	--	Grayish pigmentation of skin and membranes	--	Photographic films, jewelry, catalysts

NOTE: These measurements were taken at an activated sludge plant.

Subsequently, air, water, and urine samples were taken for the following substances.

- hexachlorocyclopentadiene (HEX)
- hexachloronorbornadiene (HEX-BCH)
- heptachlorobicycloheptene (HEX-VCL)
- chlorodene.

A urine sampling program for these chemicals was performed at the Maxson Sewage Treatment Plant in Memphis to act as a control for the study. The Maxson plant does not receive the effluent from the pesticide plant.

As shown in Table B6-1-IV, the results of the study indicate that the above chemical substances were present in the influent to the North Treatment Plant. This contamination was also detected in appreciable quantities in the air in the wet well of the facility, indicating that the chemicals had volatilized from the water into the air.

In response to a questionnaire distributed by the NIOSH study team to determine the effects of exposures, the affected employees reported the following symptoms:

- Eye irritation--110 of 200 employees complained of this symptom, and 44 reported that the symptom lasted more than 1 week.
- Headache--97 employees complained of this symptom, and 50 reported that the headache lasted more than 1 week.
- Chest discomfort--60 employees reported this effect, and 41 stated that the symptom lasted more than 1 week.
- Fatigue--60 employees suffered from fatigue and the majority (46) reported that the fatigue lasted more than 1 week.
- Sore throat--53 reported this symptom, and 20 stated that the symptom lasted more than 1 week.

Other symptoms reported during the employee survey were coughing, nausea, vomiting, and skin irritation. Several employees noted that these symptoms continued for more than 6 weeks after exposure. The reported symptoms were

TABLE B6-1-IV

A STUDY OF THE NORTH WASTEWATER TREATMENT PLANT IN MEMPHIS

Compound	TLV	Air Concentration at Wet Well	Urine Concentration	Influent Concentration
Hexachlorocyclopentadiene	100 g/M^3	0.03-39 µg/M^3	0.8-2.5 µg/l	0.8-3 µg/l
Hexachloronorbornadiene	NA	2.4-278 µg/M^3	0.3-15.2 µg/l	11-334 µg/l
Heptachlorobicycloheptene	NA	1-200 µg/M^3	NA	17-68 µg/l
Chlorodene	NA	0.5-65 µg/M^3	NA	32-216 µg/l

NA - not available

Source: Elia et al. (1980)

consistent with the known acute toxicology of hexachlorocyclopentadiene. Little is known about the chronic toxicology of this compound; however, the chronic effects could be significant if they include tumorogenesis and reproductive abnormalities similar to the effects of other chlorinated hydrocarbons.

Air samples were taken only during the cleanup operations that followed the contamination of the treatment system. Samples were taken from the area and personal samples were taken from the 97 individuals that were involved. The air sampling results are listed in Table B6-1-IV. Concentrations of hexachlorocyclopentadiene in the personal samples exceeded the TLV of 10 ppb that has been established for the compound. No TLV has been established for octachlorocyclopentene. It is clear in this case that employees of the wastewater treatment plant were adversely affected by discharge of the industrial waste and that the cleanup crew would have also been significantly affected if the problem had not been fully recognized prior to the cleanup effort (Kominsky 1980).

Although there was no attempt to determine 8-hour worker exposure levels to these chemicals, urine sampling confirmed that the worker had been exposed. Of the urine samples of 31 employees, 25% had measurable quantities of hexachlorocyclopentadiene (HEX) and 90% contained HEX-BCH.

A TLV has been established for only one of the compounds, HEX. The TLV for this compound is 100 m/M^3, which represents the concentration to which workers can be exposed for an 8-hour day without adverse health effects. The author of the study points out that "Hypothetically, if it is assumed that the TLV for HEX-BCH would be equal to the TLV for HEX (110 g/M^3 of 10 ppb), air concentrations in the wet well during May and June 1978 would be about two times this TLV level." The authors also noted that the large number of compounds that may be present in a waste treatment unit may result in additive health effects that are not adequately represented by a single TLV for one of the compounds of concern (Elia et al., 1980).

TABLE B6-1-V

AIR MEASUREMENT DURING CLEANUP OPERATIONS

Chemical	Type of Sample	No. of Samples	Concentration - ppb Mean	Concentration - ppb Median	Concentration - ppb Range
Hexachloro-cyclopentadiene	Personal	19	1,518	960	21-3,833
	Work area	41	1,446	1,286	131-4,286
Octachloro-cyclopentene	Personal	19	142	91	3-472
	Work area	41	185	189	17-416

Adapted from J.R. Kominsky et. al. (1980)

CASE STUDY II

The National Institute for Occupational Safety and Health (NIOSH) conducted a study of chemical contamination at the Morris Foreman Wastewater Treatment Plant in Louisville, Kentucky, in 1977 (Kominsky, et al., 1980). There were two incidents at the treatment unit in which a blue haze was generated at the grit chamber. The first incident occurred while workers were attempting to remove a viscous, foul-smelling substance from a screen using a steam jet. Twenty workers sought medical attention for respiratory irritation following this incident. The blue haze was observed a second time over the grit chamber and the primary treatment areas following a heavy rain.

Two chlorinated hydrocarbon constituents, hexachlorocyclopentadiene and octachlorocyclopentene, which are commonly associated with pesticide manufacturing were identified in samples of the blue haze. Contamination of the treatment system resulted from an unauthorized discharge of a chemical waste stream into the domestic sewer system.

CASE STUDY III

In February 1981 a large section of an underground sewer in Cincinnati, Ohio, collapsed. The collapse occurred following concrete pipe deterioration that was caused by a highly acidic waste stream from a pigment manufacturer. During the repair operation a number of workers were overcome by nausea, vomiting, dizziness, headache, and eye and nose irritation. The workers also complained of solvent-like odors in the sewer. A study team from NIOSH took air samples to determine whether exposure to chemicals, could be causing these symptoms. Samples were taken at the collapsed sewer repair site; at sewer hubs, life stations, and manholes; and in the sewer both upstream and downstream from the discharge point of the pigment plant. Initial monitoring showed that the concentration of Stoddard solvent below the discharge point was 780 ppm, while above the outfall the concentration was only 20 ppm. Air concentrations of several other common organic solvents were also measured.

It is clear from the data gathered by NIOSH that the concentrations of several of the organic solvents including naphtha, trichlorobenzene and Stoddard solvent were above the TLV and therefore could be hazardous to workers who may be required to enter manholes and lift stations for routine maintenance (Center for Disease Control, 1980).

CASE STUDY IV

Two sewer workers in Newark, New Jersey, were overcome by a gas consisting of various toxic chemicals, including tetrachloroethane, ethylbenzene, trichloroethylene, tetrachloroethylene, and methylisobutylketone. Exposure to the chemicals in the manhole is believed to have caused the death of one man and a severe health condition in another worker. It was suggested that the toxic chemicals were contributed from an industrial source (Bergen Record, 1981).

IMPACT OF PRETREATMENT

The limited data available provide evidence of exposure of POTW workers to industrial chemicals. Appreciable concentrations of chemicals from industrial sources have been identified in both influent water and in ambient workplace air at POTW facilities. Exposures to volatile organic compounds have caused adverse health effects among POTW workers. Pretreatment programs should reduce influent concentrations of toxic chemicals, and thus should reduce the exposure and the risk of subsequent health problems for POTW workers.

B-6-2. AIR POLLUTION IMPACTS RELATED TO POTWS

AIR POLLUTION CHARACTERIZATION

There are four types of air pollutant emissions that can be expected from the operation of POTWs. These are odorous compounds, gaseous and volatile organics, biological aerosols, and particulates. The nature and magnitude of the emission problems are a function of the processes involved and the manner in which these processes are operated. No single process is likely to encompass all the problems, although more than one problem can occur in any specific process. By far, particulate emissions, including heavy metals, are the most serious concern. In fact, particulate emissions from incinerators are subject to the New Source Performance Standards established by EPA (EPA, 1974). On the other hand, odor problems are not necessarily serious health concerns, but they often create very difficult techcnical and public relation problems. The following is a discussion of the problems associated with the four types of air pollution.

Emission of Odorous Compounds

Odorous compounds are produced in sewers and in treatment plants from organic compounds formed by hydrolysis of materials such as cystine and methionine, and by reduction of sulfates. In descending order of magnitude, methyl mercaptans, methyl sulfides, amines, indoles, skatoles, and hydrogen sulfides have been identified as the main causes of odor (Post, 1956). The processes that may evolve these compounds can be grouped ino several different categories: gases from aerobic biological processes, gases originating from certain types of algae, flow-off gases from high temperature pressure cooking processes, gases from the incomplete or improper oxidation or combustion of sludges in incinerators, gases that evaporate from exposed screenings, and gases resulting from poor housekeeping or poor plant operations (Sutton, 1971).

A treatment plant will always generate some odorous compounds, but a properly designed, operated, and maintained facility should not generate enough of these compounds to cause complaints from immediate neighbors. Occasional malfunctions in the treatment process, overloading (from industrial or domestic sources) of the treatment capacity, sudden excessive discharge of industrial wastes, and land spreading sludge are examples of condidtions likely to result in odor complaints.

Emission of Other Gaseous and Volatile Compounds

Sewage treatment plants also generate other gases and hydrocarbons that may be health and environmental concerns. Other than methane gas, most organic compounds are emitted from treatment and handling in the liquid phase. The specific species of hydrocarbons and the rate of emission will depend on the type of plant process, the condition and composition of the influent, and the size of the plant. Glaser and Ledbetter in (1969) found organic vapor concentrations of 35.2 mg/m^3 at the bar screen area, 20 mg/m^3 at the aeration tank, and 6.7 mg/m^3 at the clarifier in one activated sludge treatment plant.

Various EPA priority compounds have been identified in the influents of sewage treatment plants (EPA, 1980). Those that are volatile at ambient temperatures may evaporate in the collection or treatment systems. The 10 volatiles with the highest influent concentrations ranged from an average of 17 to 585 g/liter. Assuming that total volatile organics in the influent at a concentration of 1,000 g/liter are all evaporated, which is unlikely, a 1-MGD treatment plant will release 8.34 lb. of organics per day into the air. This loading of hydrocarbons is very low when compared to the amounts of photochemically reactive hydrocarbons permitted by air pollution control agencies. However, hydrocarbons are typically regulated by these agencies to prevent photochemical oxidation rather than to prevent toxic effects.

Many gaseous pollutants are emitted from sludge incineration operations. Hydrogen chloride, sulfur dioxide, oxides of nitrogen, and carbon monoxide have been identified in the stack gas of sludge incinerators. A study (EPA, 1975) of two fluidized beds and three multiple hearth sludge incinerators with a capacity of 500 lb./hr. to 2,500 lb./hr. found the following concentration for these gases:

Hydrogen chloride	1-10 ppm
Sulfur dioxide	0-14 ppm

Oxides of nitrogen	5-165 ppm
Carbon monoxide	0

The concentrations of these gases at ground level will be substantially lower than these values as a result of atmospheric dispersion. It is improbable that sludge incinerator emissions would cause violations of National Ambient Air Quality Standards for sulfur dioxide, oxides of nitrogen, or carbon monoxide. Although a national ambient standard for hydrogen chloride has not been set, OSHA has established an occupational exposure limit of 5 ppm. Taking into account atmospheric dispersion, ground level concentration of hydrogen chloride would be several times lower than the OSHA limit and should not cause a significant ambient impact. The sulfur dioxide concentration is well below the emission limit specified in most air pollution codes (300 ppm). As for oxides of nitrogen, the concentration is much less than that contributed by other sources. For example, Jacknow (1978) postulated that per capita emission of oxides of nitrogen from sludge incineration are equivalent to those resulting from driving an automobile for less than a tenth of a mile.

Because of the high temperature (1450°F average) required for incineration, almost all organic compounds entering the incinerator are destroyed. Localized volatization in the entrance zone of a multiple hearth incinerator could cause a small percentage of the incoming organics to be released unchanged (Jacknow, 1978). However, unless the incoming sludge has a high concentration of toxic compounds, the emission of toxic organic compounds from sludge incinerators should not result in significant environmental impacts.

Emission of Biological Aerosols

Biological aerosols can vary in size from virus units of less than 0.1 to fungal spores of 100 or larger. They may occur as single, unattached organisms or aggregates of organisms. They may adhere to a dust particle or be surrounded by a film of dried organic or inorganic material. Not all biological aerosols are harmful to humans, but airborne pathogenic microorganisms have been isolated in the vicinity of sewage treatment facilities.

Randall and Ledbetter (1966) found that 6% of all bacteria emitted from an activated sludge unit were of the Klebsiella species, a potential respiratory tract pathogen. Furthermore, approximately 40% of the viable airborne bacteria in the vicinity of the treatment unit were in the respirable size range (5μ or less). In another study (Napolitano and Rowe, 1966), the aeration tank of the activated sludge process facility and the trickling filter bed of the trickling filter process were identified as the main sources of bacteria emission.

Obviously, the spread of biological aerosols from the sewage treatment plant will be affected by wind direction and wind speed. Although biological aerosols may travel a long distance, they may not remain viable for a long time in air. For this reason, health hazards arising from pathogens in the treatment plant are only of likely concern to the plant operators. Even so, an investigation of incidence of infections among sewage plant workers (Dixon and McCabe, 1964) did not result in conclusive evidence of worker health effects.

Emission of Particulates

Particulate emission is a problem associated only with incineration of sludge. The New Source Performance Standard (EPA, 1974) sets a particulate emission limit of 0.08 grain/sdcf, or on the basis of dry sludge feed rate, 1.3 lb/ton. It also limits the plume capacity to 20%. These limits can be met with the use of high efficiency particulate emission control devices such as the high energy venturi scrubber.

Wastewater sludges contain metals that could be hazardous if discharged into the atmosphere. The forms in which the metals are found in the sludge and the operating parameters of the incinerator will affect the type of metal emission. Higher temperatures will increase the volatization of metals such as lead, mercury, and cadmium. However, it is believed that most of the metals, with the exception of mercury, are converted into oxides and appear in the particulates removed by scrubbers or other control devices, and in the ash (Dixon and McCabe, 1964).

In a study supporting the EPA mercury emission standard (EPA, 1974), 68-96% of the mercury was found to be removed by the scrubbers. Another study (Versar, 1974) showed that only 9.7% of the mercury entering a multiple-hearth furnace escaped through the scrubber and into the air. However, other studies (Dewling et al, 1980; Olexsey, 1974) have indicated that all of the mercury contained in the incoming sludge may be released into the air. These discrepancies may be attributed to the different methods used in various studies, (e.g., theoretical calculation, partial mass balance, and total mass balance). Regardless of these different findings, none of the studies have indicated any instances of the EPA mercury emission standard of 3200g per day being exceeded. In fact, tests in five incinerators (Dixon and McCabe, 1964) showed an average emission factor of 1.65g/metric ton, which would mean the operation of a 1939 metric tons/day incinerator to reach the EPA emission standard. In addition, the total mass of mercury released from a sludge incinerator is much less than that from other large point sources such as power plants or municipal incinerators. A plume dispersion modeling study (Greenberg, 1981), based on a 50g/day emission, predicted maximum ground concentrations of mercury of 27 and 29 ng/m^3 under the two most unfavorable conditions, compared to typical ambient mercury concentrations of 1-10 ng/m^3.

Aside from mercury, atmospheric emissions of other metals such as cadmium, chromium, copper, nickel, lead, and zinc from fluidized bed sludge incinerators are relatively insignificant when compared to other sources of these pollutants (Dewling et al, 1980; Greenberg et al, 1981). Most of the metals end up in the ash, with less than 1% of the metal content in the incoming sludge released into thet air. Except for lead at 2g/day and zinc at 1.5g/day, emission rates measured for other heavy metals are less than 1g/day (Greenberg et al, 1981).

It appeals that heavy metal emissions from the incineration of "typical" sewage sludge present minimal environmental hazards to the public. Mercury emissions have the greatest potential for exposing local residents, but mercury releases from sludge incinerators are small when compared to other large sources. Because of a lack of available data, conclusions can not be made about impacts resulting from the incineration of municipal sludges highly concentrated with metals.

IMPACT OF PRETREATMENT

POTW operations, especially treatment plants, wastewater collection systems, and sludge disposal methods generate air pollutants which contribute to the total atmospheric loading. However, the magnitude of these emissions is small when compared to other air pollution sources. A well designed and operated POTW whose facilities (e.g., incinerators) incorporate efficient air pollution control equipment can substantially reduce air pollutant emissions, and associated problems can be virtually eliminated.

Particulate emissions from the incineration of sludge, which include toxic heavy metals, have the potential for causing the most significant POTW-related air pollution problems. Of the heavy metals, mercury may be released from sludge incinerations in concentrations that could gave significant impacts. Other metals may also result in air pollution problems when the incinerated sludge is highly concentrated with heavy metals. However, studies have shown that incinerators, equipped with well-designed scrubbers, remove significant amounts of air pollutants.

Although POTWs are not themselves likely to create serious air pollution problems, POTW air emissions in conjunction with other sources may contribute to a total atmospheric loading which could result in violations of national or state ambient air quality standards. Pretreatment of industrial water which reduces the amount of heavy metals and organic materials introduced into POTW systems would indirectly result in lower atmospheric emissions from the POTW. In the case of odor problems where the odor results from industrial related emissions, pretreatment has the potential to completely eliminate this air pollution problem.

However, pretreatment will often result in the generation of new or additional amounts of industrial sludges. These sludges are likely to be highly contaminated with toxic pollutants and will frequently be disposed of by industrial sludge incineration. Data does not exist to quantify POTW vs. industrial pretreatment related air pollution, and such a study is beyond the scope of this report. However, it is likely that the net result would not change air pollution problems on a national scope. Considering the current state-of-the-art for pretreatment technology, it is very possible that prereatment may reduce air pollution problems for one localized area and contribute to problems in another.

B-6-3 EFFECTS OF INDUSTRIAL DISCHARGE ON GROUNDWATER

INTRODUCTION

Groundwater contamination is rapidly becoming an issue of national concern. Nearly half of the U.S. population relies directly on groundwater as a source of drinking water. Many government agencies have attempted to assess changes in the quality of the Nation's groundwater, but the magnitude of groundwater contamination is still unknown. Qualitative assessments are often the only means available for evaluating existing groundwater quality.

This section deals with only one component of the problem: can pretreatment of industrial waste appreciably minimize the degradation of groundwater quality? Like other components of the groundwater contamination problem, very little is known about the extent of the impact of untreated industrial waste on groundwater. Documented studies and case histories of these impacts provide information only on the nature of the problem, not the extent. The only means of making even a qualitative estimate of the extent of the problem is to assess current trends in the quantity and distribution of wastewater discharges.

The importance of industrial waste pretreatment in preserving the quality of groundwater resources depends on two key factors:

- The quantity of wastewater discharged by industry that can be upgraded through pretreatment activities.
- The extent to which industrial discharges can enter groundwater systems.

Trends in Industrial Discharge Practices

The point of discharge is important in evaluating industrial discharges. Table B6-3-I shows the distribution of industrial wastewater discharges for indirect discharges, from raw discharge to discharge today through anticipated discharges at full 403 (PSES). This table shows the distribution by categorical industry of the total metals and total organics in pounds discharged.

TABLE B6-3-1

VOLUMES OF WATER USE AND DISPOSAL FOR MAJOR INDUSTRIAL GROUPS
(Billions of Gallons in 1972)

Industrial Group	Total Intake	Percent of Total Intake	Total Discharge	Treated Discharge	Percent of Discharge Treated
Primary Metals	4,941	33	4,756	2,055	43
Chemicals and Allied Products	4,176	28	3,911	1,577	40
Paper and Allied Products	2,415	16	2,300	1,249	54
Petroleum and Coal Products	1,282	9	1,158	694	60
Food and Kindred Products	803	5	744	246	33
Transportation Equipment	242	2	227	43	19
Stone, Clay, and Glass Products	219	1	191	34	18
Textile Mill Products	177	1	159	68	44
Non-electrical Machinery	171	1	165	40	24
Lumber and Wood Products	159	1	122	31	25
Rubber and Plastic Products	153	1	142	26	18
Fabricated Metal Products	107	1	100	27	27
Electrical Equipment and Supplies	104	1	97	31	32
Instruments and Related Products	37	<1	34	16	47
Leather and Leather Products	8	<1	7	3	43
Furniture and Fixtures	6	<1	6	*	*
Tobacco	5	<1	4	*	*
Miscellaneous Manufacturing Industries	12	<1	11	2	18
TOTALS	15,017	100	14,134	6,142	43

Source:
*Information not disclosed.

Table B6-3-2 shows the major pollutants which comprise the discharge for some of the industries.

The pretreatment program has focused on the reduction in toxics released to the environment. However, in analyzing a need for a national program for control of toxics, or asssessment must be made of contamination to the environment from "unconventional" sources, such as leakage from sewer pi per. This leakage of wastewater from sewers is a source of groundwater contamination that has received fairly little attention. However, the 1977 Report to Congress on Waste Disposal Practices and Their Effects on Groundwater estimated that "sewer leakage on the average is probably around 5% of the total [flow]." In terms of the POTWs which are subject to pretreatment; 750 million gallons per year are released by leakage. The report attributes leakage to several factors:

- Poor workmanship, especially in the past when mortar was applied by hand as a joining material.
- Cracked or defective pipe sections.
- Breakage by tree roots penetrating or heaving the sewer lines.
- Pipeline rupture by superimposed loads, heavy equipment, or earthfill on pipe laid on a poor foundation.
- Rupture of downhill creep of soil in hilly terrain.
- Fracture and displacement of pipe by seismic activity, e.g., a sewerage system in California still suffers for fractures caused by an earthquake in 1909.
- Loss of foundation support due to underground washout.
- Poorly constructed manholes, or shearing of pipe at manholes due to differential settlement.

While cases of groundwater contamination from leaky sewers are rare, they do exist. For instance, groundwater degradation discovered in July of 1966 in Marshall County, Illinois, was traced to a leaky sewer line from an industrial plant, Walker W.H. (1969). The rareness of this type of case history is probably due to the scarcity of groundwater wells in areas served by public water supplies.

TABLE B6-3-II

INDUSTRIAL WASTEWATER PARAMETERS HAVING SIGNIFICANT GROUNDWATER CONTAMINATION POTENTIAL

PAPER AND ALLIED PRODUCTS

Pulp and Paper Industry

- COD
- TOC
- pH
- Ammonia
- Phenols
- Sulfite
- Color
- Heavy metals
- Nutrients (nitrogen and phosphorus)
- Total Dissolved Solids

PETROLEUM AND COAL PRODUCTS

Petroleum Refining Industry

- Ammonia
- Chromium
- COD
- pH
- Phenols
- Sulfide
- Total Dissolved Solids
- Chloride
- Color
- Copper
- Cyanide
- Iron
- Lead
- Mercaptans
- Nitrogen
- Odor
- Total Phosphorus
- Sulfate
- TOC
- Turbidity
- Zinc

PRIMARY METALS

- pH
- Chloride
- Sulfate
- Ammonia
- Cyanide
- Phenols
- Iron
- Cadmium
- Tin
- Chromium
- Zinc

CHEMICALS AND ALLIED PRODUCTS

Organic Chemicals Industry

- COD
- pH
- Total Dissolved Solids
- TOC
- Total Phosphorus
- Heavy metals
- Phenols
- Cyanide
- Total Nitrogen

TABLE B6-3-II (Continued)

INDUSTRIAL WASTEWATER PARAMETERS HAVING SIGNIFICANT GROUNDWATER CONTAMINATION POTENTIAL

CHEMICALS AND ALLIED PRODUCTS (Continued)

Inorganic Chemicals, Alkalies and Chlorine Industry

Acidity/Alkalinity
Total Dissolved Solids
Chloride
Sulfate
COD
TOC
Chlorinated Benzenoids and Polynuclear Aromatics
Phenols
Fluoride
Total Phosphorus
Cyanide
Mercury
Chromium
Lead
Titanium
Iron
Aluminum
Boron
Arsenic

Plastic Materials and Synthetics Industry

COD
pH
Phenols
Total Dissolved Solids
Sulfate
Phosphorus
Nitrate
Organic Nitrogen
Chlorinated Benzenoids Polynuclear Aromatics
Ammonia
Cyanide
Zinc
Mercaptans

Nitrogen Fertilizer Industry

Ammonia
Chloride
Chromium
Total Dissolved Solids
Nitrate
Sulfate
Organic Nitrogen Compounds
Zinc
Calcium
COD
Iron, Total
pH
Phosphate
Sodium

Phosphate Fertilizer Industry

Calcium
Dissolved Solids
Fluoride
pH
Phosphorus
Acidity
Aluminum
Arsenic
Iron
Mercury
Nitrogen
Sulfate
Uranium

Source: EGD, 1981.

THE ROLE OF PRETREATMENT IN GROUNDWATER CONTAMINATION

In addition to the hydrologic, climatic, and environmental conditions that exacerbate groundwater quality problems, it is important to consider background water quality and the distribution of industrial facilities across the Nation. Industries tend to concentrate in favorable localities, making, by their numbers, the groundwater basins in those areas much more susceptible to pollution than others with few industries. Pretreating wastewaters in these areas could have favorable impact in minimizing the potential for groundwater contamination.

Once an aquifer becomes polluted, recovery from that pollution usually is slow because of the generally slow rate of groundwater movement through the aquifer. Hence, groundwater pollution may be considered a semipermanent condition, perhaps lasting for decades after the source of the pollution has been determined and the pollution has been stopped. Thus, the strategy for minimizing the impacts of industrial discharges on groundwater should stress prevention rather than correction. Pretreatment would be a step toward implementing such a strategy.

Potential and existing groundwater pollution is of significant concern, not only from the standpoint of public health but also from an economic standpoint. The cost of treating water to attain an acceptable level of quality continues to increase, both because of the larger quantities of material needed to treat the water and the increasing cost of the material. It will always be less difficult and less expensive to renovate wastewater before it is discharged rather than after it has entered the groundwater system.

B-7. SUMMARY OF POTW PROBLEMS

INTRODUCTION

A number of problems exist within POTWs throughout the United States. As part of the RIA of EPA's pretreatment program, the types of POTW problems and potential causes were analyzed and evaluated. Several data bases were used in order to evaluate the scope and significance of the problems and to identify those that are common to POTWs and that can be addressed by local pretreatment. The data bases that were analyzed are presented in Appendix B to this RIA report and include:

Section	Data Base
B-1	O&M Data Base
B-2	132 POTW Local IU Control Assessment
B-3	77 POTW Visits
B-4	40 POTW Study
B-5	Pretreatment Case Studies
B-6	Worker Health and Safety, Air, and Groundwater

In each data base, potential impacts and effects on the following problems were analyzed, as appropriate:

- passthroughs
- bypasses
- process upsets
- sludge contamination
- NPDES permit violation
- problem distribution
- environmental/health concerns

This appendix and the associated sections were not developed solely to conclude a strong need for pretreatment and/or a Federal involvement, but were developed in order to quantify and depict the level of industry-related problems at POTWs and to present needs to be addressed.

POTW PROBLEMS

An analysis of these data bases indicates and verifies that there are common problems found in POTWs. These problems are national in scope and cover the full range of plant sizes and industrial mixes. The following matrix presents generic problems common to POTWs based on the data bases analyzed. Each generic problem is summarized in Table B7-I below.

TABLE B7-I

DATA BASES

Problems	O&M Data Base	132 Study	77 POTWS	40 POTWS	Case Studies
O&M and Process Upsets					Five POTWs developed local pretreatment programs prior to 40 CFR, 403 due to high costs of operation and for POTW protection.
- Associated with IU & POTWs with less than 5 MGD	79%	—	≈98%	—	
- Receive IU flows and report problems	72%	—	84%	—	
- Reporting hydraulic overloads	77%	—	—	—	
- Reporting organic overloads	42%	—	58%	—	
Permit Problems					
- Associated with IU and reporting O&M problem	80%	—	63%	—	Six developed local pretreatment programs prior to 40 CFR, 403 due to water quality (permit) problems.
- Violation and less than 5 MGD	70%	—	≈66%	—	
- Data base POTWs controlling:		POTW<5MGD<POTW			
o conventional pollutants	—	82%-85%	38%	—	
o metals	—	15%-28%	10%	—	
o toxics	—	16%-29%	4%	—	
- Violations	—	78%-62%	66%	—	
- Issued prior to 1977	—	24%-40%	—	—	
Sludge Problems					
- Sludge contamination	—	43%-69%*	20%	—	Two POTWs cited sludge handling as reason for developing local pretreatment program.
- Reported to be unsatisfactory	100% (of POTWs evaluated for sludge)	—	—	—	
- Lacking sludge quality data	—	—	30%	—	
Passthrough, Bypass, and CSO Problems					
- Reporting to receive IU flows and by-passes monthly	35%	—	—	—	—
- Area of concern	Regions II and V report highest instances	—	—	—	—
- Reporting pass-through and/or interference	—	43%-69%	—	—	—
- CSO system shows metals increase in wet condition	—	—	—	Yes	—
General					
- POTWs in some phase of pretreatment program development	—	36%-78%	100%	—	Champaign, Illinois, developed a local pretreatment program due to to new industrial growth.
- 132/77/40 Data base POTWs providing secondary treatment	97+%	75%-69%	—	—	
- 132/77/40 Data base POTWs less than 5 MGD	78%	—	98%	None	
- 132/77/40 Data based POTWs reporting to receive IU flow	21% (inaccurate reporting; may be higher)	—	—	—	
- Monitor and enforce ordinance on a regular basis	—	—	32%	—	
- POTW has conducted, or is conducting, or plans to conduct industrial waste survey	—	15%-28%	≈10%	—	
- Control all IUs by some legal mechanism.	—	52%	—	—	

O&M and Process Upsets

A high percentage of O&M and process upset problems at POTWs are associated with nondomestic (industrial) flows entering the POTW. From a review of the O&M data base and the 77 POTW visits, it can be concluded that industrial waste control will reduce O&M and process upsets and improve POTW operation.

- In the range of 5 to 100 MGD 48 to 68% of the POTWs report major and minor O&M problems associated with industrial waste.
- The percentage of industrial waste flow to a POTW is not an important parameter for determining O&M problems and violations of NPDES permits.
- Over 70% of POTWs that report receiving industrial wastes report O&M problems associated with the industrial flow.
- Of POTWs with overloads 77% report hydraulic problems and 42% report organic problems.
- O&M and sludge problems associated with industrial waste are the most often reported reasons for performance problems other than plant obsolescence.
- The most commonly listed problem industries are: food, electroplating, mechanical products, and textiles.

Permit Problems

An large percentage of POTWs violate their current NPDES permits. In addition, these permits will be updated to provide control on priority pollutants. The data presented in these analyses and summarized below indicate that there will probably be POTW permit problems associated with industrial flows.

- More than 80% of the POTWs in the O&M data base that report O&M problems associated with industrial wastes violate their NPDES permit.
- Of the POTWs in the 77 POTW data base with permit violations, 65% reported nondomestic flows as contributors.
- Almost 70% of all POTWs violate their NPDES permit, with approximately 50% of them in violation 10% or more of the time.
- Approximately 80% of all permits address only conventional pollutants with 30-40% of current permits having been issued prior to 1977.

- Approximately 50% of POTWs have some level of control (ordinance, permit, etc.) on all industrial users in their system, but approximately 70% do not monitor on a regular basis.

Sludge Problems

As summarized below, the analyses indicate that sludge contamination is primarily associated with the concentration of metals in the POTW sludge. As more POTWs opt for land-based disposal options, the metal concentrations could become critical.

- Heavy metals removed at POTWs are incorporated into the sludge of the POTWs.
- POTWs in the O&M data base that were evaluated for sludge problems reported that their sludge disposal practices and/or costs are about 100% dissatisfactory.
- Of the POTWs in the 77 POTW data base, 87% report sludge contamination contributed by industrial wastes.
- The 77 POTW data base indicates that 30% of the POTWs are not aware of their sludge quality.

Passthrough, Bypass, and CSO Problems

The data available are insufficient to analyze passthrough of toxics organics. In bypass situations all pollutants are discharged into the receiving waters and there is a potential for toxic pollutants to enter the environment. The O&M data base yields the following:

- Approximately 35% of the POTWs bypass monthly for varying time periods of up to 24 hours per month.
- The highest reported instances of bypass occur in Regions II and V. The states in EPA Region V are heavily industrialized and the potential exists for industrial pollution due to bypassing.
- The 40 POTW study found increased heavy metal concentrations in (CSO) systems due to wet conditions. This may be due to flushing of metals that settle during dry conditions.

General

POTWs have operational problems that are influenced by the industrial flows entering their systems. A number of POTWs do not report industrial flows because they do not know the volume, but they report industrial wastes as contributors to their O&M, sludge, and permit problems.

- In the 40 POTW Study, industry was found to be the major contributor of priority pollutants to POTWs. Variations in priority pollutant concentrations can be attributed to the types and sizes of industries discharging into the POTW.
- Approximately 25 organics, 8 heavy metals, and cyanide are normally found in POTW influent.
- A number of POTWs report O&M problems due to industrial wastes but do not report industrial flow quantities into their facility.
- Approximately 70+% of POTWs reporting industrial waste flows provide secondary treatment, and are less than 5 MGD.
- POTWs meeting secondary treatment requirements provide good removal of priority pollutants. Generally, these POTWs remove 80%-75% or more of the heavy metals, 80% of the total volatile organics, and 70% of the total acid-base-neutral organic pollutants.
- High concentrations of priority pollutants in the POTW influent encourage high removal efficiency across the POTW.
- 68% of the POTWs do not monitor or enforce their industrial users on a regular basis (at least once per year), and of the remaining 32% that monitor for conventional pollutants, 12% monitor metals and 1.3% monitor for toxics.
- POTWs that have existing pretreatment programs have lower concentrations of priority pollutants in the POTW influent and effluent. For example, total metals were 28% higher in the influents of POTWs and 34% higher in effluents without pretreatment. These trends carried through for acid-base-neutrals--76% and 59% for influent and effluent respectively, and volatiles--315% and 299%, respectively.

APPENDIX C

INTRODUCTION

To assess the environmental, health, and cost impacts and benefits of pretreatment program alternatives, JRB developed a mathematical model of the 2,000 POTWs required to adopt a program. The POTW model reviews each of the 2,000 POTWs requiring pretreatment, determines and quantifies the pretreatment options for each, and then aggregates the results in order to estimate the national impact, and to serve as a decision-making tool.

Appendix C is divided into the following four sections:

- C-1 Overview of the POTW Model
- C-2 Data Sources
- C-3 POTW Model Methodology, Assumptions and Documentation
- C-4 POTW Model Results and Analysis

Appendix C-1 discusses the POTW model selection and conceptualization of the model, approach of the model, and aggregation of the modeling calculations.

Appendix C-2 provides a description of the data sources used by the Model. The model relies heavily on existing, centralized data bases such as the Needs Survey, Dun and Bradstreet, and the Permit Compliance System. In general, the data collected from these sources is specific to the 2,000 municipalities required to adopt a program.

Appendix C-3 describes the details of the computer model. the computer model calculates the following:

- Impacts Related to Industrial Users - including environmental effects such as sludge quality and quantity, and effluent quality; and financial effects such as pretreatment-related costs and sludge disposal costs.

- Impacts Related to POTWs - including environmental effects such as influent and effluent concentrations, receiving stream flow, water quality impacts, sludge quality and air emissions of volatile toxic pollutants, and cost factors such as municipal pretreatment program costs.

Appendix C-4 includes a discussion of the model's outputs and compares these results to other EPA measures. The sensitivity of the model to various factors is also addressed.

C-1. OVERVIEW OF THE POTW MODEL

POTW MODEL SELECTION

During the early stages of this task JRB studied and reviewed several analytical methods for quantifying the regulatory impact of various pretreatment strategies. The models evaluated include: a nationwide combined model, a POTW model and a case study model.

The nationwide combined method would have involved compilation of all the 2,000 POTWs requiring pretreatment and consideration of them as one large national POTW. In this manner, a gross analysis of each of the options could have been made. However, after the data collection task was completed, a preliminary analysis of the data indicated that POTW characteristics and problems are largely localized and unique to the individual POTW. The nationwide combined method would be too inprecise, as it would ignore the individual characteristics of the POTWs and make comparisons between the options meaningless or unclear.

The POTW model method examined each of the 2,000 POTWs requiring pretreatment, for a variety of pretreatment options, and then aggregated the results for estimating the national impact of each option. This method collected data for POTWs from the Needs Data base, the 40 POTW Study, Effluent Guidelines Data (EGD), Dun & Bradstreet (D&B) and Pollution Control System (PCS) data for industry, and Office of Solid Waste data. In developing the analytical model to perform this method, the Environmental Protection Agency (EPA) made the following assumptions:

- Conventional pollutants would not be treated in the model except for their effect on sludge quantities.
- POTW sludge was assumed to be non-hazardous, regardless of the concentration of priority pollutants.
- Industrial sludge was assumed to be hazardous and had one disposal cost, independent of the disposal method used.

The POTW model developed used a mass balance approach to determine the quality and quantity of POTW effluent, sludge contamination, quantity of water quality violations, and industrial and municipal pretreatment program costs. Individual variables which compare each option are inserted into the model and applied to each POTW. Although POTW results were aggregated, each POTW could be analyzed individually or in subgroups to determine the effects on individual POTW types. The individual POTW results are not generally applicable for purposes other than aggregation unless the data input sources were changed.

The use of case study model exclusively would have involved considerable field visits and primary data collection with the further commitment of time and resources. However, rather than expand the information base, it was decided to review the existing published data, (see Appendices B-1 through B-7). Attention was directed toward specific POTW problems such as upsets, intereferences and bypass not treated in the POTW computer model. Information on approximately 1,750 POTWs is documented through these studies. In addition to POTW operational data, pretreatment program motivation, effluent quality, worker health and safety, air quality, and estimates of the amount of "grandfathering" in place were other issues analyzed.

CONCEPTUALIZATION OF THE MODEL

One of the principal purposes of the Regulatory Impact analysis (RIA) is to obtain quantitative information on the costs and the benefits associated with industrial pretreatment of wastewater. The data presented in Appendix B summarized the qualitative data, previous data compilations, and case studies that pertain to pretreatment, and drew appropriate conclusions from each. However, a natural extension of these results would be to prepare a precise model that could quantify some of the known pretreatment-related costs and benefits and that would serve as a valuable decisionmaking tool. Additionally, the model could predict some of the parameters that could not be qualitatively discussed in Appendix B. The model is basically organized into three modules:

(1) A regulatory alternative, which influences both the data selected from appropriate data bases and the major baseline assumptions.

(2) Effects of that alternative on industry, including environmental effects (sludge quality and quantity, effluent quality, etc.) and cost effects (pretreatment technology cost, hazardous sludge disposal, etc.).

(3) Effects of that alternative on POTWs, including operational effects, (POTW sludge quality and quantity, effluent quality, etc.) cost effects (pretreatment program implementation and development costs), and environmental effects (water quality changes resulting from POTW effluent and stream flow, volatilization of toxic organic pollutants, etc.).

The following sections detail how the above factors were modeled, and what the overall modeling approach involved.

APPROACH OF THE MODEL

It was first decided to computerize the entire modeling effort. Computerization would:

- Facilitate data input from sources that were already computerized (e.g., STORET, the NEEDS Survey, Dun and Bradstreet, Permit Compliance system, etc.) and quickly handle the magnitude of the input data required to accurately simulate the interactions of industry, the POTW, and the environment.

- Allow a microanalysis for a large number of POTW systems, and easily make the number of simulation runs, with slightly modified assumptions, to analyze the sensitivity of the assumption.
- Permit a precise analysis that includes as much of the nation as possible.
- Facilitate modifications and changes in assumptions or data elements in order to test additional alternatives quickly in the late stages of the analysis.
- Be available for subsequent use in other EPA programs that could benefit from a precise simulation of a POTW.
- Be more cost-effective than other methods of achieving the same results.

Next, a flow chart of the major modeling steps was developed. A simplified chart is presented in Figure C3-1 (p. C-20). The first major step was to read the input data. The data sources are described in detail in Section C-2, but the major items and their sources are:

- Number of industrial users (Dun and Bradstreet)
- Number of directly discharging industrial users (Permit Compliance System)
- Average flow per industrial user in each category (EPA EGD)
- Average effluent quality per industrial user in each category (EPA EGD)
- Removal required per industrial user in each category (EPA EGD)
- Cost of pretreatment technology per industrial user (EPA EGD)
- POTW statistics, i.e., flow, level of treatment (EPA NEEDS Survey)
- POTW removal efficiency (EPA 40 POTW Study)
- POTW nonindustrial contributions EPA 40 POTW and 4-City Study
- Sludge disposal costs (EPA estimates)
- Stream flows for each POTW, STORET, USGS.

TABLE C2-I. MAJOR DATA SOURCES USED BY THE COMPUTER MODEL

DATA GROUP	DATA INPUT ELEMENT	Dun & Bradstreet	EPA Permit Compliance System	EPA Needs Survey	EPA Effluent Guideline Div. Data	40 POTW Study	4 City Study	Engineering Calculations	U.S. Geological Survey & STORET	EPA Regulations/Estimates	EPA Office of Water Program Operations	NCHA Publications	General Technical Literature
POTW Data	POTW ID & Location			●									
	POTW Flow			●									
	POTW Level of Treatment			●									
	Methods of Sludge Disposal Used by POTW			●									
	POTW Removal Efficiency of Priority Pollutants					●		●					●
Data On Industrial Users	Industrial Flow to POTW			●									
	Number of IU's per Category	●											
	Total Number of Direct IU's per Category		●										
	Total Number of Industrial Plants per Category in U.S.				●								
	Total Number of Direct Industrial Dischargers Per Category in US				●								
	Average Model Industrial Plant Flow per Category				●								
	Raw Waste Concentrations				●								
	Raw Waste Concent. Assuming No Pretreatment In Place (Baseline)				●								
Sludge Generation Data	Industrial Sludge Generation Rates							●					●
	Municipal Sludge Generation Rates							●					●
	Average Receiving Stream Flows								●				
	Low Receiving Stream Flows								●				
	Receiving Stream Water Quality Criteria for Aquatic Life									●			
	Receiving Stream Water Quality Criteria for Public Health									●			
	Volatilization Rate of Volatile Toxic Organics					●		●					
Cost Data	Unit Cost for Pretreatment Technology				●								
	Cost Estimate for Development of Local Pretreatment Programs							●			●		
	Cost Estimate for Implementation of Local Pretreatment Programs							●			●		
	Unit Industrial Sludge Disposal Cost									●		●	
	Unit Municipal Sludge Disposal Cost Per Method									●		●	
Miscellaneous Data	Pollutant Concen. Contrib. by Non-Indus. Sources to Model POTW					●	●						
	Matching between SIC Codes and Category Codes				●								

After the input of all data, the model was used to calculate the appropriate outputs The key computations performed were:

- Identification of all industrial users served by a POTW. This involved correlating Dun and Bradstreet/Permit Compliance files to the proper categorical industry and determining how many indirect dischargers exist.
- Prediction of the average effluent flow and characteristics, and the pretreatment cost for industrial users. These data primarily related data from EGD to the actual industrial user count and flow at each POTW.
- Addition of a baseline concentration of toxic pollutants to account for domestic and commercial contributions. These data were calculated from two EPA studies: the 40 POTW study and the 4-City study.
- Adjustment of each industrial user flow to reflect the actual industrial flow at that POTW (called "normalization"). The actual POTW flow and industrial flow were based on the NEEDS Survey.
- Calculation of a POTW influent based on the previous three steps.
- Application of an average POTW removal efficiency for each toxic pollutant depending on the POTW level of treatment, and subsequent calculation of the POTW effluent and sludge concentrations of toxic pollutants.
- Determination of the effects of the POTW effluent on stream quality and its contribution to potential water quality violations. The POTW effluent was divided by the actual stream dilution ratio (based on stream flow) to determine these impacts.
- Calculation of the industry-related costs (pretreatment technology and hazardous sludge disposal) based on industrial user count and industrial flow.
- Calculation of POTW pretreatment program development and implementation costs based on the POTW flow, industrial flow, and number and variety of industrial user's present.

AGGREGATION OF THE MODELING CALCULATIONS

The last step in the modeling effort was to prepare an aggregate summary table presenting the national costs and the net improvement in water, air, and sludge quality. The aggregation output can be used to compare the results of various pretreatment options. Items that appeared in the aggregation summary include:

- Industrial sludge quantity and quality for significant toxic pollutants, and disposal costs
- POTW sludge quantity and concentration of toxic pollutants
- POTW influent and effluent quality
- Applicable water quality and health criteria
- Ambient stream concentration (POTW effluent concentration/dilution ratio)
- Average incremental percent of water quality criteria consumed by the POTW discharged
- Number of POTWs exceeding water quality criteria as well as human health standards.

In general, the model appears to be a credible simulation of a POTW system. The model does have a number of specified and implied assumptions, and some weaknesses was designed primarily to indicate specific differences between various pretreatment options. Accordingly, the results calculated for any particular POTW are often inaccurate because of the generalizations and normalization assumptions needed to design the model and because of certain data deficiencies. Nonetheless, the aggregate results closely represent the actual cost and environmental effects expected from pretreatment. The major omissions and assumptions of the modeling exercise that affect the conclusions are:

POTW Model Weaknesses

- Conventional pollutants are not addressed, except as they affect sludge production. EPA data for each of the categorical industries does not always have sufficient data on treatability of conventionals and removal by pretreatment technologies to be incorporated into the model. This deficiency could be remedied in future analyses.
- The POTW removal efficiency for each pollutant in the model is identical for all POTWs within a given level of treatment. The most representative data on priority pollutant removal by a POTW is the EPA

40 POTW study which only includes well operating plants, the median removals from this study are used in the model. As a result, the estimates of possible water quality violations are probably a minimum. The averaging effect of this assumption tends to further minimize the water quality impacts calculated by the model.

- The model assumes that municipal sludge is always non-hazardous. The cost of municipal sludge disposal is, therefore, not a function of level of contamination with toxic pollutants from industry -- no matter how severe the contamination. Consequently, improved sludge quality will not have quantifiable economic effect in the model. If EPA issued new sludge criteria, then certain sludge disposal options utilized by POTWs might need to be replaced by more costly options. This result could greatly increase the cost effectiveness of some pretreatment options.
- Ambient water quality data for toxic pollutants is not available for most water bodies. Therefore, the model could not calculate the incremental degradation caused by the POTW discharge. As a result the actual number of violations are likely to be substantially higher than those calculated by the model. Especially when several POTWs are on one stretch of a stream. The model can be made to take into account other discharges so that the marginal water quality impacts of each POTW can be calculated.

Industrial Model Weaknesses

- The only common denominator between the NEEDS Survey information of POTWs and D&B identification of IUs is the city name. Consequently, IUs within a POTW service area but in a suburb or different city will not be counted in this method. This affects the distribution of industry in each POTW simulation. This error can greatly affect an individual POTW, but has an overall minimal effect on the aggregate results.
- Within cities with multiple POTWs, D&B cannot distinguish which POTW services each IU discharges. This error is minimized by the flow normalization procedure described in Appendix C-3.
- Each IU is assumed to have the characteristics of the EGD model plant. As a result, the characteristics of an individual POTW will contain errors related to the degree to which actual IUs in that system vary from the national composite. Again, this assumption leads to an understatement of water quality impacts.
- EGD has not entirely verified all organic priority pollutant discharge data from industry categories. Consequently total toxic organics had to be treated as a group in the model rather than individually. Therefore, the model does not now estimate water quality criteria exceedences for toxic organic pollutants.

Overall Data Weaknesses

- The Needs Survey only provided data for 1,839 POTWs of the 2,000 cities. These cities are, however, believed to be representative of all cities.
- The bench mark for water quality impacts of POTW discharges on the model is the Federal Water Criteria, and Drinking Water Standards. State standards were evaluated but were not found to be better for use in the model. It is important to note that the use of criteria only can indicate trends in water quality, but not a count of actual violations.
- Stream flow data is only available for 703 streams (only 665 that matched the 1,839 POTWs) from computerized data bases and other readily accessible information.

Aggregate results are more representative of national cost and environmental impacts than is the result for a particular POTW. Inaccuracies in individual POTWs could be minimized by improving the quality of the input data. For example, by contacting the POTW to determine its actual service area, the accuracy of local industrial pretreatment costs and industry discharge calculations could be improved. Thus the model could become a more useful predictive tool for local POTWs or regional areas than it is using nationwide data bases. Using local site-specific water quality and local sludge would enable the model to be used to optimize the development of such advance limits on their industrial discharge control measures at specific POTWs.

C-2. DATA SOURCES

A broad approach ws applied to data collection efforts for the RIA. In an attempt to be as thorough and all-inclusive as possible and to ensure that modeling results were accurate. The following pages present the major data sources used in the model and a description of how each was applied to it. These sources are:

- Dun and Bradstreet Marketing Services (Dun and Bradstreet 1981)

- Permit Compliance System (U.S. EPA 1981)
- EPA Supplied Data (DENIT 1981, O'Farrell 1981)
- NEEDS Survey (U.S. EPA 1980)
- 40 POTW Study (Feiler 1980, Southworth 1981)
- 4-City Study (Adams 1981)
- STORET/USGS (U.S. EPA 1981)
- Pretreatment Program Costs.

The overall limitations of the data are also summarized in the following discussion.

DUN AND BRADSTREET MARKETING SERVICES

Dun and Bradstreet Marketing Services (D&B) has compiled a list of many industrial, commercial, and service firms in the United States as a credit service to its clients. Categorized by Standard Industrial Classification (SIC) code and city, this data base represents the most complete centralized listing of manufacturing facilities that was available for the RIA. The D&B computer tapes were requested for those cities containing the 2,000 POTWs required to implement the General Pretreatment Regulations, and by the deadline for this report, information was supplied for all of these. Several problems with the D&B data as applied to RIA were recognized:

- D&B listings could only be obtained for industrial users in the same city as the POTW. Data could not be obtained for industrial users that discharged to regional POTWs, but were located in nearby cities or suburbs.
- Where cities had multiple POTWs, D&B data could not identify where any particular industrial user discharged.
- D&B listings included direct, indirect, and zero discharges.
- D&B listings were based on SIC codes, which did not always match EGD estimates for categorized industries.

JRB checked at random several POTWs that had completed industrial waste surveys and compared those data with D&B listings. Overall, the data were consistent; consequently, subject to the above constraints and the adjustments that were made, D&B counts were used as the basis for identifying the industries present in a POTW system.

PERMIT COMPLIANCE SYSTEM

The Permit Compliance System (PCS) is a data management system designed to track the conditions detailed in NPDES permits. For purposes of the RIA, the only data extracted from PCS were counts of direct discharging facilities in each city by SIC code. These counts were subtracted from the D&B counts to approximate the number of industrial users indirectly discharging to the POTW. PCS counts were also the primary data source for estimating the number of metal finishers in each POTW (see Appendix C-3).

EPA-SUPPLIED DATA

For each categorical industry, and for several noncategorical industries, the Effluent Guidelines Division (EGD) of EPA provided estimates of the number of facilities nationwide that discharge to POTWs, their total flow, quantity of several toxic pollutants, best estimates of removals that would be required under Pretreatment Standards for Existing Sources (PSES) and the resulting pretreatment technology costs (O'Farrell 1981). By necessity, these estimates were used to predict what characteristics each individual plant in each category would contain. The EGD also supplied estimates of the total number of plants in each category (direct, indirect, and zero dischargers). These estimates were used to adjust D&B national counts to ensure consistency between the two data bases.

The EGD estimates of current raw waste loads, which were used to profile existing POTW conditions, accounted for the amount of pretreatment already in place. A separate set of raw waste load data with no pretreatment was also provided by EGD, as a measure of the mangitude of toxic pollutant control achieved to date.

The pretreatment technology cost data from EGD were provided as a national total for each categorical industry. This total was converted to a cost per unit of flow, which varied between categories, and was applied to the flow from facilities in each SIC code category. The required long-term average removals by PSES were EGD estimates, since few regulations have yet been issued.

EPA has also supplied other assumptions and data throughout the development of the model, on such items as sludge disposal costs and adjustments to industrial user totals.

EPA NEEDS SURVEY

The NEEDS Survey is designed to determine the cost of needed treatment work and sewer system construction. The survey is performed every 2 years, and the summarized results are reported to Congress. The costs predicted by the Survey are used by the states and EPA as a basis for allocating these funds. Surveys of construction needs have been conducted since 1969; the first to include a prediction of the costs to meet future goals (1983) was performed in 1972, the year that major changes were made in the Federal Water Pollution Control Act. The most current completed survey (1980) was used in the RIA model to obtain information for each of the 1,839 POTW's where both D&B and the NEEDS Survey data were available. The principal data items extracted from the NEEDS Survey include:

- POTW identification
- POTW flow
- POTW industrial flow
- City, state, and region
- Level of treatment
- Sludge disposal method(s) used.

The POTW city name provided the common denominator for D&B counts of various industries. The POTW flow and industrial flow determined the flow normalization procedure used in the model.

40 POTW STUDY

From 1978 to 1980, the EGD conducted an intensive sampling program at 40 POTWs to characterize the fate and occurrence of toxic pollutants in POTWs. This study was fully described in Section B-4. Basically it consisted of week-long sampling of 40 POTWs' influent, effluent, and sludge streams for conventional and priority pollutants. The data from this study had three basic uses in this model:

(1) It was the primary source for data on the removal of toxic pollutants by POTWs.

(2) It, along with the 4-City Study, was the basis for estimating the nonindustrial contribution of toxic pollutants to POTWs.

(3) It was used to verify many of the outputs for the model.

The 40 POTW Study compiled data on influent and secondary effluent at 40 reasonably well-operated POTWs that had at least secondary treatment. These data formed the basis of secondary removal levels for each toxic pollutant that were required for the model. Of the 40 POTWs, 7 also had tertiary treatment in place and operating at the time of sampling, and data from these POTWs constituted the POTW tertiary removal data. Although primary effluent samples were collected at approximately one-third of the 40 POTWs, it was judged that primary effluent at secondary POTWs did not reflect that of primary plants for a variety of reasons, including interferences from recycle lines. Consequently, primary removal of toxic pollutants was estimated from one of the 40 POTWs that had no recycle lines, and from literature sources.

Two of the 40 POTWs sampled received virtually no industrial wastewater. These POTWs were used as one benchmark of the nonindustrial priority pollutant loading expected from domestic and commercial sources. A second study used to determine nonindustrial contribution is described in the following section.

EPA 4-CITY STUDY

During 1978 and 1979 the Monitoring and Data Support Division of EPA conducted a source sampling survey of 4 POTW collection systems. Sampling in all 4 cities was conducted in interceptors from domestic, commercial, and industrial users, and at the POTW influent. The industrial component of this study was not used in the RIA because the four collection systems did not include a sufficient variety of EPA's categorical industries. However, the domestic and commercial results were used in the model as a second measure of nonindustrial contribution. It is important to note that two of the four cities in this study were the two plants from the 40 POTW study that had little industry. All four cities were included in the 40 POTW sampling.

STORET/USGS

Where available, stream flow data for each POTW was collected from the STORET and U.S. Geological Survey (USGS) data bases, supplemented by EPA's Basin Characteristics File. At this time, data are only available for 703 streams matching the 2,000 cities that require pretreatment programs and for 665 of the streams corresponding to the 1,839 POTWs for which D&B data and NEEDS Survey data were both available.

PRETREATMENT PROGRAM DEVELOPMENT AND IMPLEMENTATION COSTS

JRB prepared two independent cost estimates of pretreatment program costs: the first based on engineering estimates by individuals who were experienced in developing these programs for municipalities, and the second a statistical analysis of data supplied by cities that had completed such programs, with costs drawn from their 201 Grant applications. Both cost estimates are displayed in the computer model.

DATA BASE LIMITATIONS

Overall, the many data sources provide excellent information on the 2,000 POTWs. However, some of the data are being used for purposes other than those intended at the time of data collection and may have some inaccuracies. The generalized limitations of the data are described in the following paragraphs.

The number and type of industrial users serving a POTW can not be properly approximated by using D&B counts for industrial users in the city where the POTW is located, because regional plants that serve two or more communities will undercount the industrial users, while cities with more than one POTW will count the same industrial users twice or more. Adjustments were made between the national total of plants counted by D&B and by EPA to normalize the total national counts. However, any single POTW may be significantly misrepresented. The major limitation of the data, therefore, is not whether the absolute D&B count for each SIC code is accurate, but whether the ratio of plants in each category reflects the actual distribution in that POTW system.

The industrial users in each category at each POTW were all assumed to have the model plant flow and effluent quality predicted by EPA. On an aggregate basis this will result in a total similar to EPA's estimated total, but again an individual POTW's influent may have far different characteristics than those predicted by the model, depending on how closely their industrial users match EPA's model plants.

The majority of the environmental quality calculations performed in the model are based on the computed influent quality and the individual industrial wastestreams. On the POTW level, these outputs are affected by the factors discussed above. There are also other assumptions in the model relating to treatment efficiency and sludge production, which treat all POTWs as "average" plants. However, these assumptions have less impact on the results than the above factors.

C.3 MODEL METHODOLOGIES AND ASSUMPTIONS

The computer modeling effort has been described in general terms in previous sections of the RIA. This Appendix provides the specific methodology employed by the model, relates the data sources to the model's algorithms, and details the explicit and implicit assumptions made. Appendix C-3 is divided into subsections which correspond to the major tasks within the model, and which are based on the general design described in Appendix C-1.

A simplified flow chart of the model is presented in Figure C3-1. It represents the data inputs received and the major outputs prepared. Table C2-I, previously presented in Appendix C-2, is repeated here as Table C3-I. This table indicates the relationship of the data sources to the needed inputs of the model.

INDUSTRIAL MODULE OF THE MODEL

Identification of all Industrial Users (IU's) Served by a POTW and Calculation of the Total Industrial Flow and Pollutant Loading to the POTW

The industrial component of POTW flow was determined by the following steps:

1. The number of Industrial Users (IUs) was first computed by counting the D&B responses(1) for each SIC code in the city matching the POTW location city from the Needs Survey. The SIC code responses were then assigned to appropriate categorical industries according to definitions supplied by EGD. A listing of these definitions is presented in Table C3-II.

2. Because D&B site descriptions and counts are often more broadly defined than EGD estimates of actual manufacturing sites, the D&B counts were adjusted according to the following ratio (calculated for each categorical industry):

$$\text{Adjustment Factor} = \frac{\text{Total Number of Plants Estimated by EGD Nationwide}}{\text{Total Number of Plants Counted by D\&B Nationwide}}$$

   The adjustment factors derived are listed in Table C3-III.

3. A count of direct dischargers in each city was obtained from the PCS database. These counts were assigned to the proper categorical

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(1) D&B responses keyed only on primary SIC codes for each site.

Figure C3-1. Simplified Flow Chart of the Computer Model

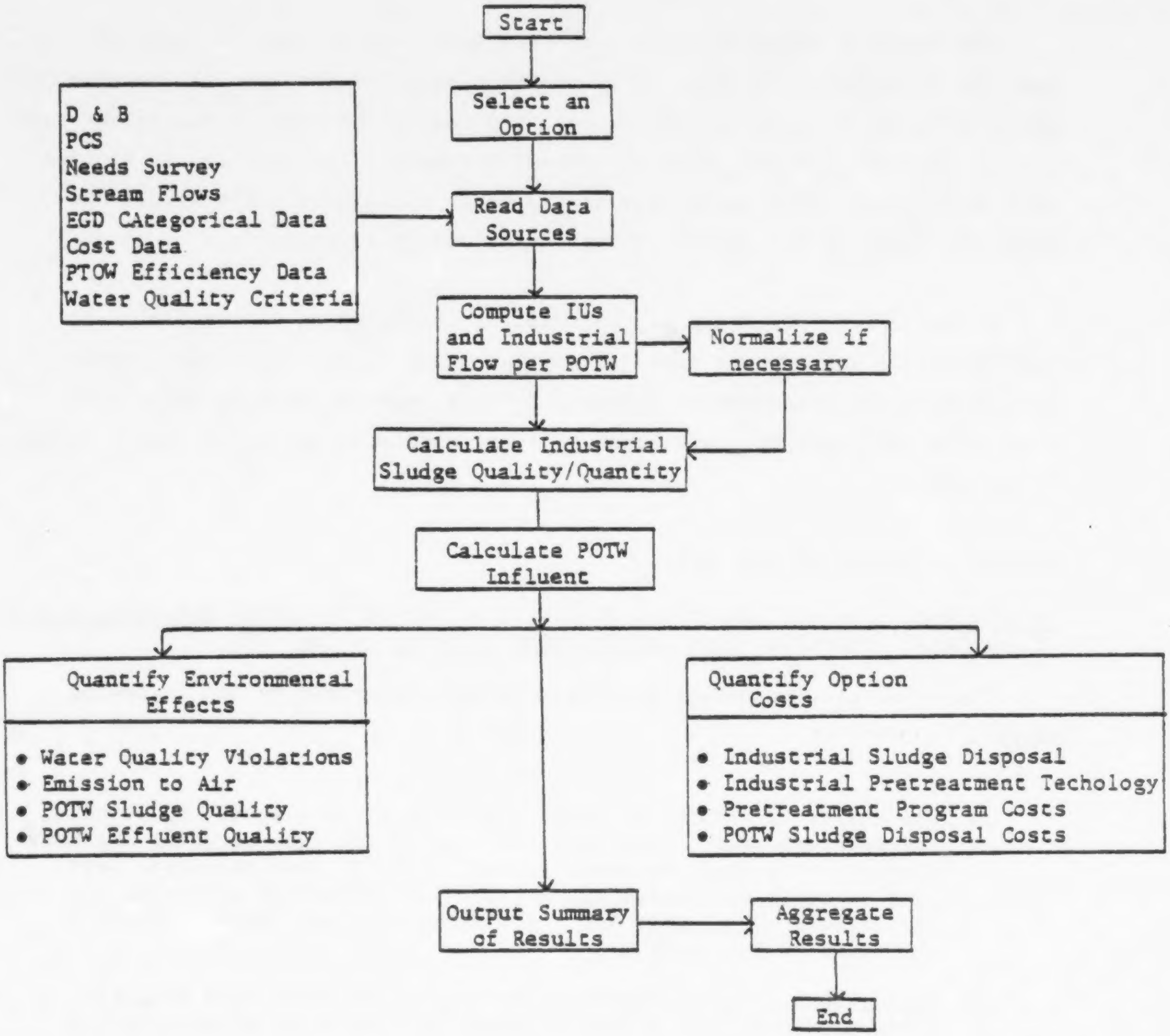
Start
Select an Option
D & B
PCS
Needs Survey
Stream Flows
EGD CAtegorical Data
Cost Data
PTOW Efficiency Data
Water Quality Criteria
Read Data Sources
Compute IUs and Industrial Flow per POTW
Normalize if necessary
Calculate Industrial Sludge Quality/Quantity
Calculate POTW Influent
Quantify Environmental Effects
• Water Quality Violations
• Emission to Air
• POTW Sludge Quality
• POTW Effluent Quality
Quantify Option Costs
• Industrial Sludge Disposal
• Industrial Pretreatment Techology
• Pretreatment Program Costs
• POTW Sludge Disposal Costs
Output Summary of Results
Aggregate Results
End

TABLE C3-I. MAJOR DATA SOURCES USED BY THE COMPUTER MODEL

DATA GROUP	DATA INPUT ELEMENT	Dun & Bradstreet	EPA Permit Compliance System	EPA Needs Survey	EPA Effluent Guideline Div. Data	40 POTW Study	4 City Study	Engineering Calculations	U.S. Geological Survey & STORET	EPA Regulations/Estimates	EPA Office of Water Program Operations	RCRA Publications	General Technical Literature
POTW Data	POTW ID & Location			●									
	POTW Flow			●									
	POTW Level of Treatment			●									
	Methods of Sludge Disposal Used by POTW			●									
	POTW Removal Efficiency of Priority Pollutants					●		●					●
Data On Industrial Users	Industrial Flow to POTW			●									
	Number of IU's per Category	●											
	Total Number of Direct IU's per Category		●										
	Total Number of Industrial Plants per Category in U.S.				●								
	Total Number of Direct Industrial Dischargers Per Category in US				●								
	Average Model Industrial Plant Flow per Category				●								
	Raw Waste Concentrations				●								
	Raw Waste Concent. Assuming No Pretreatment In Place (Baseline)				●								
Sludge Generation Data	Industrial Sludge Generation Rates							●					●
	Municipal Sludge Generation Rates							●					●
	Average Receiving Stream Flows								●				
	Low Receiving Stream Flows								●				
	Receiving Stream Water Quality Criteria for Aquatic Life									●			
	Receiving Stream Water Quality Criteria for Public Health									●			
	Volatilization Rate of Volatile Toxic Organics					●		●					
Cost Data	Unit Cost for Pretreatment Technology				●								
	Cost Estimate for Development of Local Pretreatment Programs							●			●		
	Cost Estimate for Implementation of Local Pretreatment Programs							●			●		
	Unit Industrial Sludge Disposal Cost									●		●	
	Unit Municipal Sludge Disposal Cost Per Method									●		●	
Miscellaneous Data	Pollutant Concen. Contrib. by Non-Indus. Sources to Model POTW					●	●						
	Matching between SIC Codes and Category Codes				●								

TABLE C3-II. MATCHING OF SIC CODES WITH CATEGORICAL INDUSTRIES

1 ADHESIVES	2891	
2 ALUMINUM FORMING	3354	
2 ALUMINUM FORMING	3355	
2 ALUMINUM FORMING	3357	
2 ALUMINUM FORMING	3398	
2 ALUMINUM FORMING	3411	
2 ALUMINUM FORMING	3463	
3 AUTO & OTHER LAUNDRIES	7213	
3 AUTO & OTHER LAUNDRIES	7218	
3 AUTO & OTHER LAUNDRIES	7542	
4 BATTERY MANUFACTURING	3691	
4 BATTERY MANUFACTURING	3692	
5 COAL MINING	1111	
5 COAL MINING	1112	
5 COAL MINING	1211	
5 COAL MINING	1213	
6 COIL COATING	3479	
7 COPPER FORMING	3351	
7 COPPER FORMING	3357	
7 COPPER FORMING	3463	
8 ELECTRICAL PRODUCTS	3674	
9 ELECTROPLATING (Job Shops)	3471	
9 ELECTROPLATING (Job Shops)	3479	
10 EXPLOSIVES MANUFACTURING	2892	
11 FOUNDRIES	3361	
11 FOUNDRIES	3362	
11 FOUNDRIES	3369	
11 FOUNDRIES	3321	
11 FOUNDRIES	3322	
11 FOUNDRIES	3323	
11 FOUNDRIES	3324	
11 FOUNDRIES	3325	
12 GUM & WOOD CHEMICALS	2861	
13 INORGANIC CHEMICALS	2812	
13 INORGANIC CHEMICALS	2813	
13 INORGANIC CHEMICALS	2816	
13 INORGANIC CHEMICALS	2819	
14 IRON & STEEL	3312	
14 IRON & STEEL	3313	
14 IRON & STEEL	3315	
14 IRON & STEEL	3316	
14 IRON & STEEL	3317	
15 LEATHER TANNING & FINISHING	3111	
16 MECHANICAL PRODUCTS	2511	Electroplating Captive Shops
16 MECHANICAL PRODUCTS	2514	
16 MECHANICAL PRODUCTS	2522	
16 MECHANICAL PRODUCTS	2531	
16 MECHANICAL PRODUCTS	2542	
16 MECHANICAL PRODUCTS	2591	
16 MECHANICAL PRODUCTS	2599	
16 MECHANICAL PRODUCTS	3069	
16 MECHANICAL PRODUCTS	3079	
16 MECHANICAL PRODUCTS	3293	
16 MECHANICAL PRODUCTS	3312	
16 MECHANICAL PRODUCTS	3315	
16 MECHANICAL PRODUCTS	3317	
16 MECHANICAL PRODUCTS	3321	
16 MECHANICAL PRODUCTS	3325	
16 MECHANICAL PRODUCTS	3341	
16 MECHANICAL PRODUCTS	3351	
16 MECHANICAL PRODUCTS	3354	
16 MECHANICAL PRODUCTS	3356	
16 MECHANICAL PRODUCTS	3357	
16 MECHANICAL PRODUCTS	3361	
16 MECHANICAL PRODUCTS	3362	
16 MECHANICAL PRODUCTS	3369	Electroplating Captive Shops
16 MECHANICAL PRODUCTS	3398	
16 MECHANICAL PRODUCTS	3399	
16 MECHANICAL PRODUCTS	3400	
16 MECHANICAL PRODUCTS	3401	
16 MECHANICAL PRODUCTS	3402	
16 MECHANICAL PRODUCTS	3403	
16 MECHANICAL PRODUCTS	3404	
16 MECHANICAL PRODUCTS	3405	
16 MECHANICAL PRODUCTS	3406	
16 MECHANICAL PRODUCTS	3407	
16 MECHANICAL PRODUCTS	3408	
16 MECHANICAL PRODUCTS	3409	
16 MECHANICAL PRODUCTS	3410	
16 MECHANICAL PRODUCTS	3412	
16 MECHANICAL PRODUCTS	3413	
16 MECHANICAL PRODUCTS	3414	
16 MECHANICAL PRODUCTS	3415	
16 MECHANICAL PRODUCTS	3416	
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16 MECHANICAL PRODUCTS	3457	
16 MECHANICAL PRODUCTS	3458	
16 MECHANICAL PRODUCTS	3459	
16 MECHANICAL PRODUCTS	3460	
16 MECHANICAL PRODUCTS	3461	
16 MECHANICAL PRODUCTS	3462	
16 MECHANICAL PRODUCTS	3464	
16 MECHANICAL PRODUCTS	3465	

TABLE C3-II. MATCHING OF SIC CODES WITH CATEGORICAL INDUSTRIES (Con't)

16 MECHANICAL PRODUCTS	Electroplating Captive Shops	3466
16 MECHANICAL PRODUCTS		3467
16 MECHANICAL PRODUCTS		3468
16 MECHANICAL PRODUCTS		3469
16 MECHANICAL PRODUCTS		3470
16 MECHANICAL PRODUCTS		3472
16 MECHANICAL PRODUCTS		3473
16 MECHANICAL PRODUCTS		3474
16 MECHANICAL PRODUCTS		3475
16 MECHANICAL PRODUCTS		3476
16 MECHANICAL PRODUCTS		3477
16 MECHANICAL PRODUCTS		3478
16 MECHANICAL PRODUCTS		3480
16 MECHANICAL PRODUCTS		3481
16 MECHANICAL PRODUCTS		3482
16 MECHANICAL PRODUCTS		3483
16 MECHANICAL PRODUCTS		3484
16 MECHANICAL PRODUCTS		3485
16 MECHANICAL PRODUCTS		3486
16 MECHANICAL PRODUCTS		3487
16 MECHANICAL PRODUCTS		3488
16 MECHANICAL PRODUCTS		3489
16 MECHANICAL PRODUCTS		3490
16 MECHANICAL PRODUCTS		3491
16 MECHANICAL PRODUCTS		3492
16 MECHANICAL PRODUCTS		3493
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16 MECHANICAL PRODUCTS		3495
16 MECHANICAL PRODUCTS		3496
16 MECHANICAL PRODUCTS		3498
16 MECHANICAL PRODUCTS		3499
16 MECHANICAL PRODUCTS		3500
16 MECHANICAL PRODUCTS		3501
16 MECHANICAL PRODUCTS		3502
16 MECHANICAL PRODUCTS		3503
16 MECHANICAL PRODUCTS		3504
16 MECHANICAL PRODUCTS		3505
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16 MECHANICAL PRODUCTS		3511
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16 MECHANICAL PRODUCTS		3531
16 MECHANICAL PRODUCTS		3532
16 MECHANICAL PRODUCTS		3533
16 MECHANICAL PRODUCTS		3534
16 MECHANICAL PRODUCTS	Electroplating Captive Shops	3535
16 MECHANICAL PRODUCTS		3536
16 MECHANICAL PRODUCTS		3537
16 MECHANICAL PRODUCTS		3538
16 MECHANICAL PRODUCTS		3539
16 MECHANICAL PRODUCTS		3540
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16 MECHANICAL PRODUCTS		3564
16 MECHANICAL PRODUCTS		3565
16 MECHANICAL PRODUCTS		3566
16 MECHANICAL PRODUCTS		3567
16 MECHANICAL PRODUCTS		3568
16 MECHANICAL PRODUCTS		3569
16 MECHANICAL PRODUCTS		3570
16 MECHANICAL PRODUCTS		3571
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16 MECHANICAL PRODUCTS		3573
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16 MECHANICAL PRODUCTS		3590
16 MECHANICAL PRODUCTS		3591
16 MECHANICAL PRODUCTS		3592
16 MECHANICAL PRODUCTS		3593
16 MECHANICAL PRODUCTS		3594
16 MECHANICAL PRODUCTS		3595
16 MECHANICAL PRODUCTS		3596
16 MECHANICAL PRODUCTS		3597
16 MECHANICAL PRODUCTS		3598
16 MECHANICAL PRODUCTS		3599
16 MECHANICAL PRODUCTS		3600

TABLE C3-II. MATCHING OF SIC CODES WITH CATEGORICAL INDUSTRIES (Con'd)

16 MECHANICAL PRODUCTS	Electroplating Captive Shops	3601
16 MECHANICAL PRODUCTS		3602
16 MECHANICAL PRODUCTS		3603
16 MECHANICAL PRODUCTS		3604
16 MECHANICAL PRODUCTS		3605
16 MECHANICAL PRODUCTS		3606
16 MECHANICAL PRODUCTS		3607
16 MECHANICAL PRODUCTS		3608
16 MECHANICAL PRODUCTS		3609
16 MECHANICAL PRODUCTS		3610
16 MECHANICAL PRODUCTS		3611
16 MECHANICAL PRODUCTS		3614
16 MECHANICAL PRODUCTS		3615
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16 MECHANICAL PRODUCTS		3637
16 MECHANICAL PRODUCTS		3638
16 MECHANICAL PRODUCTS		3640
16 MECHANICAL PRODUCTS		3642
16 MECHANICAL PRODUCTS		3643
16 MECHANICAL PRODUCTS		3645
16 MECHANICAL PRODUCTS		3646
16 MECHANICAL PRODUCTS		3647
16 MECHANICAL PRODUCTS		3648
16 MECHANICAL PRODUCTS		3649
16 MECHANICAL PRODUCTS		3650
16 MECHANICAL PRODUCTS		3651
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16 MECHANICAL PRODUCTS		3665
16 MECHANICAL PRODUCTS		3666
16 MECHANICAL PRODUCTS		3667
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16 MECHANICAL PRODUCTS		3670
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16 MECHANICAL PRODUCTS		3682
16 MECHANICAL PRODUCTS		3683
16 MECHANICAL PRODUCTS		3684
16 MECHANICAL PRODUCTS	Electroplating Captive Shops	3685
16 MECHANICAL PRODUCTS		3686
16 MECHANICAL PRODUCTS		3687
16 MECHANICAL PRODUCTS		3688
16 MECHANICAL PRODUCTS		3689
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16 MECHANICAL PRODUCTS		3695
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16 MECHANICAL PRODUCTS		3697
16 MECHANICAL PRODUCTS		3698
16 MECHANICAL PRODUCTS		3700
16 MECHANICAL PRODUCTS		3701
16 MECHANICAL PRODUCTS		3702
16 MECHANICAL PRODUCTS		3703
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16 MECHANICAL PRODUCTS		3752
16 MECHANICAL PRODUCTS		3753
16 MECHANICAL PRODUCTS		3754
16 MECHANICAL PRODUCTS		3755

TABLE C3-II. MATCHING OF SIC CODES WITH CATEGORICAL INDUSTRIES (Cont'd)

16 MECHANICAL PRODUCTS	3756	Electroplating Captive Shops
16 MECHANICAL PRODUCTS	3757	
16 MECHANICAL PRODUCTS	3758	
16 MECHANICAL PRODUCTS	3759	
16 MECHANICAL PRODUCTS	3760	
16 MECHANICAL PRODUCTS	3761	
16 MECHANICAL PRODUCTS	3762	
16 MECHANICAL PRODUCTS	3763	
16 MECHANICAL PRODUCTS	3764	
16 MECHANICAL PRODUCTS	3765	
16 MECHANICAL PRODUCTS	3766	
16 MECHANICAL PRODUCTS	3767	
16 MECHANICAL PRODUCTS	3768	
16 MECHANICAL PRODUCTS	3769	
16 MECHANICAL PRODUCTS	3770	
16 MECHANICAL PRODUCTS	3771	
16 MECHANICAL PRODUCTS	3772	
16 MECHANICAL PRODUCTS	3773	
16 MECHANICAL PRODUCTS	3774	
16 MECHANICAL PRODUCTS	3775	
16 MECHANICAL PRODUCTS	3776	
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16 MECHANICAL PRODUCTS	3782	
16 MECHANICAL PRODUCTS	3783	
16 MECHANICAL PRODUCTS	3784	
16 MECHANICAL PRODUCTS	3785	
16 MECHANICAL PRODUCTS	3786	
16 MECHANICAL PRODUCTS	3787	
16 MECHANICAL PRODUCTS	3788	
16 MECHANICAL PRODUCTS	3789	
16 MECHANICAL PRODUCTS	3790	
16 MECHANICAL PRODUCTS	3791	
16 MECHANICAL PRODUCTS	3792	
16 MECHANICAL PRODUCTS	3793	
16 MECHANICAL PRODUCTS	3794	
16 MECHANICAL PRODUCTS	3795	
16 MECHANICAL PRODUCTS	3796	
16 MECHANICAL PRODUCTS	3797	
16 MECHANICAL PRODUCTS	3798	
16 MECHANICAL PRODUCTS	3799	
16 MECHANICAL PRODUCTS	3800	
16 MECHANICAL PRODUCTS	3801	
16 MECHANICAL PRODUCTS	3802	
16 MECHANICAL PRODUCTS	3803	
16 MECHANICAL PRODUCTS	3804	
16 MECHANICAL PRODUCTS	3805	
16 MECHANICAL PRODUCTS	3806	
16 MECHANICAL PRODUCTS	3807	
16 MECHANICAL PRODUCTS	3808	
16 MECHANICAL PRODUCTS	3809	
16 MECHANICAL PRODUCTS	3810	
16 MECHANICAL PRODUCTS	3811	
16 MECHANICAL PRODUCTS	3812	
16 MECHANICAL PRODUCTS	3813	
16 MECHANICAL PRODUCTS	3814	
16 MECHANICAL PRODUCTS	3815	
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16 MECHANICAL PRODUCTS	3817	
16 MECHANICAL PRODUCTS	3818	
16 MECHANICAL PRODUCTS	3819	
16 MECHANICAL PRODUCTS	3820	
16 MECHANICAL PRODUCTS	3821	
16 MECHANICAL PRODUCTS	3822	Electroplating Captive Shops
16 MECHANICAL PRODUCTS	3823	
16 MECHANICAL PRODUCTS	3824	
16 MECHANICAL PRODUCTS	3825	
16 MECHANICAL PRODUCTS	3826	
16 MECHANICAL PRODUCTS	3827	
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16 MECHANICAL PRODUCTS	3884	
16 MECHANICAL PRODUCTS	3885	
16 MECHANICAL PRODUCTS	3886	
16 MECHANICAL PRODUCTS	3887	
16 MECHANICAL PRODUCTS	3888	

TABLE C3-II. MATCHING OF SIC CODES WITH CATEGORICAL INDUSTRIES (Cont'd)

16 MECHANICAL PRODUCTS	3889	Electroplating Captive Shops
16 MECHANICAL PRODUCTS	3890	
16 MECHANICAL PRODUCTS	3891	
16 MECHANICAL PRODUCTS	3892	
16 MECHANICAL PRODUCTS	3893	
16 MECHANICAL PRODUCTS	3894	
16 MECHANICAL PRODUCTS	3895	
16 MECHANICAL PRODUCTS	3896	
16 MECHANICAL PRODUCTS	3897	
16 MECHANICAL PRODUCTS	3898	
16 MECHANICAL PRODUCTS	3899	
16 MECHANICAL PRODUCTS	3900	
16 MECHANICAL PRODUCTS	3901	
16 MECHANICAL PRODUCTS	3902	
16 MECHANICAL PRODUCTS	3903	
16 MECHANICAL PRODUCTS	3904	
16 MECHANICAL PRODUCTS	3905	
16 MECHANICAL PRODUCTS	3906	
16 MECHANICAL PRODUCTS	3907	
16 MECHANICAL PRODUCTS	3908	
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16 MECHANICAL PRODUCTS	3926	
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16 MECHANICAL PRODUCTS	3950	
16 MECHANICAL PRODUCTS	3951	
16 MECHANICAL PRODUCTS	3952	
16 MECHANICAL PRODUCTS	3953	
16 MECHANICAL PRODUCTS	3954	
16 MECHANICAL PRODUCTS	3955	Electroplating Captive Shops
16 MECHANICAL PRODUCTS	3956	
16 MECHANICAL PRODUCTS	3957	
16 MECHANICAL PRODUCTS	3958	
16 MECHANICAL PRODUCTS	3959	
16 MECHANICAL PRODUCTS	3960	
16 MECHANICAL PRODUCTS	3961	
16 MECHANICAL PRODUCTS	3962	
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16 MECHANICAL PRODUCTS	3977	
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16 MECHANICAL PRODUCTS	3980	
16 MECHANICAL PRODUCTS	3981	
16 MECHANICAL PRODUCTS	3982	
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16 MECHANICAL PRODUCTS	3984	
16 MECHANICAL PRODUCTS	3985	
16 MECHANICAL PRODUCTS	3986	
16 MECHANICAL PRODUCTS	3987	
16 MECHANICAL PRODUCTS	3988	
16 MECHANICAL PRODUCTS	3989	
16 MECHANICAL PRODUCTS	3990	
16 MECHANICAL PRODUCTS	3991	
16 MECHANICAL PRODUCTS	3992	
16 MECHANICAL PRODUCTS	3993	
16 MECHANICAL PRODUCTS	3994	
16 MECHANICAL PRODUCTS	3995	
16 MECHANICAL PRODUCTS	3997	
16 MECHANICAL PRODUCTS	3998	
16 MECHANICAL PRODUCTS	3999	
17 NON-FERROUS METALS	3331	
17 NON-FERROUS METALS	3332	
17 NON-FERROUS METALS	3334	
17 NON-FERROUS METALS	3339	
17 NON-FERROUS METALS	3341	
18 ORE MINING & DRESSING	1011	
18 ORE MINING & DRESSING	1021	
18 ORE MINING & DRESSING	1037	
18 ORE MINING & DRESSING	1041	
18 ORE MINING & DRESSING	1044	
18 ORE MINING & DRESSING	1051	
18 ORE MINING & DRESSING	1061	
18 ORE MINING & DRESSING	1092	
18 ORE MINING & DRESSING	1094	
18 ORE MINING & DRESSING	1099	
19 ORGANIC CHEMICALS	2865	
19 ORGANIC CHEMICALS	2869	
20 PAINT & INK	2851	
20 PAINT & INK	2893	
21 PESTICIDES	2879	
22 PETROLEUM REFINING	2911	
23 PHARMACEUTICALS	2831	

TABLE C3-II. MATCHING OF SIC CODES WITH CATEGORICAL INDUSTRIES (Cont'd)

23	PHARMACEUTICALS	2833
23	PHARMACEUTICALS	2834
24	PHOTOGRAPHIC SUPPLIES	3861
25	PLASTICS & SYNTHETICS	2821
25	PLASTICS & SYNTHETICS	2823
25	PLASTICS & SYNTHETICS	2824
26	PLASTICS PROCESSING	3079
27	PORCELAIN ENAMELING	3429
27	PORCELAIN ENAMELING	3431
27	PORCELAIN ENAMELING	3631
27	PORCELAIN ENAMELING	3632
27	PORCELAIN ENAMELING	3633
27	PORCELAIN ENAMELING	3639
28	PRINTING & PUBLISHING	2711
28	PRINTING & PUBLISHING	2712
28	PRINTING & PUBLISHING	2713
28	PRINTING & PUBLISHING	2714
28	PRINTING & PUBLISHING	2715
28	PRINTING & PUBLISHING	2716
28	PRINTING & PUBLISHING	2717
28	PRINTING & PUBLISHING	2718
28	PRINTING & PUBLISHING	2719
28	PRINTING & PUBLISHING	2720
28	PRINTING & PUBLISHING	2721
28	PRINTING & PUBLISHING	2722
28	PRINTING & PUBLISHING	2723
28	PRINTING & PUBLISHING	2724
28	PRINTING & PUBLISHING	2725
28	PRINTING & PUBLISHING	2726
28	PRINTING &PUBLISHING	2727
28	PRINTING & PUBLISHING	2728
28	PRINTING & PUBLISHING	2729
28	PRINTING & PUBLISHING	2730
28	PRINTING & PUBLISHING	2731
28	PRINTING & PUBLISHING	2732
28	PRINTING & PUBLISHING	2733
28	PRINTING & PUBLISHING	2734
28	PRINTING & PUBLISHING	2735
28	PRINTING & PUBLISHING	2736
28	PRINTING & PUBLISHING	2737
28	PRINTING & PUBLISHING	2738
28	PRINTING & PUBLISHING	2739
28	PRINTING & PUBLISHING	2740
28	PRINTING & PUBLISHING	2741
28	PRITING & PUBLISHING	2742
28	PRINTING & PUBLISHING	2743
28	PRINTING & PUBLISHING	2744
28	PRINTING & PUBLISHING	2745
28	PRINTING & PUBLISHING	2746
28	PRINTING & PUBLISHING	2747
28	PRINTING & PUBLISHING	2748
28	PRINTING & PUBLISHING	2749
28	PRINTING & PUBLISHING	2750
28	PRINTING & PUBLISHING	2751
28	PRINTING & PUBLISHING	2752
28	PRINTING & PUBLISHING	2753
28	PRINTING & PUBLISHING	2754
28	PRINTING & PUBLISHING	2755
28	PRINTING & PUBLISHING	2756
28	PRINTING & PUBLISHING	2757
28	PRINTING & PUBLISHING	2758
28	PRINTING & PUBLISHING	2759
28	PRINTING & PUBLISHING	2760
28	PRINTING & PUBLISHING	2761
28	PRINTING & PUBLISHING	2762
28	PRINTING & PUBLISHING	2763
28	PRINTING & PUBLISHING	2764
28	PRINTING & PUBLISHING	2765
28	PRINTING & PUBLISHING	2766
28	PRINTING & PUBLISHING	2767
28	PRINTING & PUBLISHING	2768
28	PRINTING & PUBLISHING	2769
28	PRINTING & PUBLISHING	2770
28	PRINTING & PUBLISHING	2771
28	PRINTING & PUBLISHING	2772
28	PRINTING & PUBLISHING	2773
28	PRINTING & PUBLISHING	2774
28	PRINTING & PUBLISHING	2775
28	PRINTING & PUBLISHING	2776
28	PRINTING & PUBLISHING	2777
28	PRINTING & PUBLISHING	2778
28	PRINTING & PUBLISHING	2779
28	PRINTING & PUBLISHING	2780
28	PRINTING & PUBLISHING	2781
28	PRINTING & PUBLISHING	2782
28	PULP, PAPER & FIBERBOARD	2661
29	PULP, PAPER & FIBERBOARD	2611
29	PULP, PAPER & FIBERBOARD	2621
29	PULP, PAPER & FIBERBOARD	2631
29	PULP, PAPER & FIBERBOARD	2661
30	NON-CATEGORICAL IND.	2032
30		2033
30		2034
30		2035
30		2037
30		2038
30		2099
30		2021
30		2022
30		2023
30		2024
30		2026
30		2091
30		2092
30		5146
30		5423
30		2016
30		2017
30		2041
30		2043
30		2044
30		2045
30		2046
30		2048
30		2011
30		2013
30		2017
30		2034
30		2038
30		2047
30		2051
30		2052
30		2065
30		2066
30		2067
30		2074
30		2075
30		2076
30		2079
30		2082
30		2083
30		2084

TABLE C3-II. MATCHING OF SIC CODES WITH CATEGORICAL INDUSTRIES (Cont'd)

30		2085
30		2086
30		2087
30		2095
30		2097
30		2098
30		2099
30		5144
30		5182
31	SOAPS & DETERGENTS	2841
31	SOAPS & DETERGENTS	2842
31	SOAPS & DETERGENTS	2843
32	STEAM ELECTRIC	4911
32	STEAM ELECTRIC	4931
33	TEXTILE MILLS	2210
33	TEXTILE MILLS	2211
33	TEXTILE MILLS	2212
33	TEXTILE MILLS	2213
33	TEXTILE MILLS	2214
33	TEXTILE MILLS	2215
33	TEXTILE MILLS	2216
33	TEXTILE MILLS	2217
33	TEXTILE MILLS	2218
33	TEXTILE MILLS	2219
33	TEXTILE MILLS	2220
33	TEXTILE MILLS	2221
33	TEXTILE MILLS	2222
33	TEXTILE MILLS	2223
33	TEXTILE MILLS	2224
33	TEXTILE MILLS	2225
33	TEXTILE MILLS	2226
33	TEXTILE MILLS	2227
33	TEXTILE MILLS	2228
33	TEXTILE MILLS	2229
33	TEXTILE MILLS	2230
33	TEXTILE MILLS	2231
33	TEXTILE MILLS	2232
33	TEXTILE MILLS	2233
33	TEXTILE MILLS	2234
33	TEXTILE MILLS	2235
33	TEXTILE MILLS	2236
33	TEXTILE MILLS	2237
33	TEXTILE MILLS	2238
33	TEXTILE MILLS	2239
33	TEXTILE MILLS	2240
33	TEXTILE MILLS	2241
33	TEXTILE MILLS	2242
33	TEXTILE MILLS	2243
33	TEXTILE MILLS	2244
33	TEXTILE MILLS	2245
33	TEXTILE MILLS	2246
33	TEXTILE MILLS	2247
33	TEXTILE MILLS	2248
33	TEXTILE MILLS	2249
33	TEXTILE MILLS	2250
33	TEXTILE MILLS	2251
33	TEXTILE MILLS	2252
33	TEXTILE MILLS	2253
33	TEXTILE MILLS	2254
33	TEXTILE MILLS	2255
33	TEXTILE MILLS	2256
33	TEXTILE MILLS	2257
33	TEXTILE MILLS	2258
33	TEXTILE MILLS	2259
33	TEXTILE MILLS	2260
33	TEXTILE MILLS	2261
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33	TEXTILE MILLS	2285
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33	TEXTILE MILLS	2288
33	TEXTILE MILLS	2289
33	TEXTILE MILLS	2291
33	TEXTILE MILLS	2292
33	TEXTILE MILLS	2295
33	TEXTILE MILLS	2296
33	TEXTILE MILLS	2297
33	TEXTILE MILLS	2298
33	TEXTILE MILLS	2299
34	TIMBER PRODUCTS PROCESSING	2491
34	TIMBER PRODUCTS PROCESSING	2661
34	TIMBER PRODUCTS PROCESSING	2499

TABLE C3-III
SIC ADJUSTMENT FACTORS

	INDUSTRY	ADJUSTMENT FACTOR
1.	Adhesives/Sealants	0.658
2.	Aluminum Forming	0.199
3.	Auto & Other Laundries	1.0
4.	Battery Manufacturing	0.69
5.	Coal Mining	1.691
6.	Coil Coating	0.036
7.	Copper Forming	0.385
8.	Electrical Products	0.322
9.	Electroplating Job Shops	1.0
10.	Explosives Manufacturing	1.521
11.	Foundries	0.417
12.	Gum & Wood Chemicals	0.14
13.	Inorganic Chemicals	0.058
14.	Iron & Steel	0.358
15.	Leather Tanning & Finishing	0.291
16.	Electroplating Captive Shops	1.0
17.	Non-Ferrous Metals	0.322
18.	Ore Mining & Dressing	1.0
19.	Organic Chemicals	1.223
20.	Paint & Ink Formulation	0.837
21.	Pesticides Manufacturing	0.215
22.	Petroleum Refining	0.042
23.	Pharmaceuticals Manufacturing	0.173
24.	Photographic Supplies	0.082
25.	Plastics & Synthetics	1.0
26.	Plastics Processing	1.0
27.	Porcelain Enameling	0.045
28.	Printing & Publishing	0.949
29.	Pulp, Paper & Fiberboard	0.444
30.	Non-Categorical Industries	0.2
31.	Soaps & Detergents	0.596
32.	Steam Electric Power Generation	0.189
33.	Textile Mills	0.199
34.	Timber Products & Processing	0.103

industry according to the same definitions described in Table C3-II. This PCS count was subtracted from the adjusted D&B count (Step 2) to result in the estimated number of indirect discharges to a POTW. In the few instances where PCS was greater than adjusted D&B, the counts were set equal to 0.

4. For two categorical industries (metal finishers - job shops and metal finishers - captive shops) a different approach was used. For captives the number of indirect dischargers was defined as 3 times the number of direct dischargers (from PCS). For job shops, the number of indirect dischargers was defined as 9 times the number of direct dischargers. This approach was necessitated by the larger number of sites that are defined as metal finishers according to the SIC code definition but generate no wastewater. EPA consequently decided that the above approach would result in the best approximation of metal finisher distribution. Implicitly however, this approach assumes that indirect dischargers are geographically distributed among cities proportionally to direct dischargers.

5. One categorical industry, rubber manufacturing, was not addressed by the model because industry data from EGD was not available. Since there are almost no indirectly discharging rubber plants the error of this assumption is small.

6. EGD supplied an assumed model plant flow as well as effluent characteristics for each of the categorical industries. The effluent description included specific concentrations for the priority pollutant metals, but for some industries only a total concentration of the organic priority pollutants. This flow and effluent characteristic was used for each categorical industry to determine the industrial component of the POTW flow and toxic loading as follows:

$$\text{Industrial Flow} = \left(\sum_{i=1}^{34} \begin{matrix}\text{indirect}\\ \text{IU count}\end{matrix} \right)_i \left(\text{Q model} \right)_i$$

$$\text{Industrial Priority Pollutant Loading} = \sum_{i=1}^{34} (\text{Indirect IU count})_i * (\text{Cmodel}_i)$$

where Q = flow and C = concentration.

The information supplied by EGD is detailed in the Tables C3-IV and C3-V to this section. The user of one model plant flow and one assumed effluent concentration has the effect of minimizing the variability of industrial flow and wasteload to the POTW. However, the following section will indicate how the model attempted to negate these limitations by relying only on the distribution of industry and not the actual IU count.

TABLE C3-IV

Average Flow (CQ model) of Model Industrial User

Category	Average Flow (mgd)
1. Adhesives & Sealants	0.0106
2. Aluminum Forming	0.0822
3. Auto & Other Laundries	0.0062
4. Battery Manufacturing	0.0254
5. Coal Mining	0.0
6. Coil Coating	0.065
7. Copper Forming	0.112
8. Electrical & Electronic Products	0.088
9a. Electroplating & Job Shops	0.019
9b. Electroplating & Captive Shops	0.069
10. Explosives Manufacturing	0.008
11. Foundries	0.061
12. Gum & Wood Chemicals	0.233
13. Inorganic Chemical Mfg.	0.664
14. Iron & Steel	0.017
15. Leather Tanning	0.221
16. Mechanical Products	0.0
17. Non-Ferms Metals	0.041
18. Ore Mining & Dressing	0.0
19. Organic Chemical Mfg.	0.802
20. Paint & Ink Formulating	0.0007
21. Pesticides	0.0937
22. Petroleum Refining	0.0936
23. Phamaceutical Mfg.	0.1561
24. Photographic Equip. & Supplies	0.0117
25. Plastic & Synthetics	0.802
26. Plastic Dressing	0.01
27. Porcelain Enameling	0.0067
28. Printing & Publishing	0.0028
29. Pulp, Paper & Fiberboard	0.878
30. Rubber	0.0
31. Soap & Detergent Mfg.	0.0553
32. Steam Electric Power Generation	0.1414
33. Textile	0.2187
34. Timber	0.14457
35. Non-Categorical Industries	0.113

Table C3-V

Industrial Wastewater Characteristics
(mg/l)

Pollutant	Adhesives & Sealants	Aluminum Forming	Auto other Laundries	Battery Manufacturing	Coal Mining	coil Coating	Copper Forming	Electrical & Electronic Products
Silver (Aq)	0	0		0.028		0	0	0
Arsenic (As)	0	0		0.0012		0	0	0.28
Beryllium (Be)	0	0		0.		0	0	0
Cadmium (Cd)	0	0.016		0.644		0	0	0.003
Total Chromium (Cr)	0	44.631		0.494		21.32	0.041	0.284
Copper (Cu)	0	125.9		0.261		0	36.749	0.872
Mercury (Hg)	0	0		0.130		0	0	0.009
Nickel (Ni)	0	0.221		1.164		0.147	1.185	1.051
Lead (Pb)	0	0.174		3.764		0	0.215	0.117
Antimony (Sn)	0	0		0		0	0	0
Selenium (Se)	0	0		0		0	0	0
Thallium (Th)	0	0		0		0	0	0
Zinc (Zn)	0	114.75		5.959		0.6	8.641	0.125
Cyanide (Cn)	0	0.085		0.008		0.147	0	0.006
Toxic Organics	0	0.014		0.008		0.253	0	3.581
Pesticides	0	0		0		0	0	0
BOD		0		0		0	0	0
TSS		62.617		1165.936		67.95	4.602	0
Ammonia		0		0		0	0	0
Oil & Grease		28.644		55.326		119.9	42.235	0
Pretreatment Tech. Cost/$1000 gal.	8	$22.00		8.20		2.80	1.40	25.00

Table C3-V (Continued)

Industrial Wastewater Characteristics
(mg/l)

Pollutant	Metal Finishing Job Shops	Mechanical Products: Captive Shops	Explosive Manufacturing	Foundires	Gum Wood Chemicals	Inorganic Chemical Mfg.	Iron & Steel	Leather Tanning
Silver (Aq)	0.02	0.019			0.0002	0.0001	0.6676	0
Arsenic (As)	0	0			0.006	0.0022	1.736	0
Beryllium (Be)	0	0			0	0	0	0
Cadmium (Cd)	0.24	0.059			0.00003	0.016	1.736	0.002
Total Chromium (Cr)	23.4	5.5			0.079	1.459	58.48	59.634
Copper (Cu)	11	2.8			0.310	0.002	28.31	0.128
Mercury (Hg)	0	0			0	0.0002	0	0
Nickel (Ni)	13	3.4			0.045	0.0002	108.82	0.077
Lead (Pb)	0.28	0.093	10.791	0.455	0.021	0.024	47.26	0.922
Antimony (Sn)	0	0		0	0	0	0	0
Selenium (Se)	0	0		0	0	0	0	0
Thallium (Th)	0	0		0	0	0	0	0
Zinc (Zn)	10	2.6		3.036	0.521	1.319	235.66	0.483
Cyanide (Cn)	8.3	2.0		0	0.004	0.001	62.75	0.073
Toxic Organics	0	0		0.911	1.053	0	150.87	0
Pesticides	0	0		0	0	0	0	0.176
BOD	0	0	41.97	0	981.18	0	0	1439.91
TSS	667	667	26.38	415.87	153.6	0	35782.3	2228.31
Ammonia	0	0		0	0	0	0	0
Oil & Grease	0	0		24.284	376.17	0	17624.12	350.162
Pretreatment Tech. Cost/$1000 gal	1.96	3.17		1.80	--	0	N.A.	5.30

Table C3-V (Continued)

Industrial Wastewater Characteristics
(mg/l)

Pollutant	Non-Forous Metal	Ore Mining & Dressing	Organic Chem. Mfg.	Paint & Ink Formulating	Pesticides	Petroleum Refining	Pharmaceutical Mfg.	Photographic Equip. & Supplies
Silver (Aq)	0.702		0.0007	0	0.0005	0	0	1.0569
Arsenic (As)	3.026		0.001	0.03	0.0042	0.0179	0	0.0476
Beryllium (Be)	0		0	0	0	0	0	0
Cadmium (Cd)	0.382		0.017	0.316	0.0008	0	0	0.6961
Total Chromium (Cr)	0.36		0.054	0.536	0.0101	1.0597	0.0147	0.1679
Copper (Cu)	1.038		0.280	1.956	0.6641	0.0199	0.0184	0.1894
Mercury (Hg)	0.008		0.001	0.139	0.0002	0.009	0.0005	0.0178
Nickel (Ni)	1.042		0.011	0.133	0.1199	0.0019	0.0262	0.0021
Lead (Pb)	2.345		0.036	0.757	0.008	0.0179	0.0110	0.2055
Antimony (Sn)	0		0	0	0	0	0	0
Selenium (Se)	0		0	0	0	0	0	0
Thallium (Th)	0		0	0	0	0	0	0
Zinc (Zn)	10.314		0.201	75.729	0.6641	0.5298	0.0918	1.267
Cyanide (Cn)	0.017		0.096	0.631	0.7563	2.517	0.0314	0.3522
Toxic Organics	0.081		1347.83	25.243	22.1361	13.345	0	0.1744
Pesticides	0		0	0	0	0	0	0
BOD	0		39.385	5301.022	0	100.67	203.45	969.51
TSS	130.758		55.138	631.741	0	90.736	124.46	356.29
Ammonia	0		0	0	0	0	0	0
Oil & Grease	2.477		0	1454.704	0	84.770	0	14.099
Pretreatment Tech. Cost/ 1000 gal	7.90		1.30	34.00	12.00	--	--	--

Table C3-V (Continued)

Industrial Wastewater Characteristics
(mg/l)

Pollutant	Plastic & Synthetics	Plastic Processing	Procelain Enameling	Pulp Printing Publishing	Paper & Fiberboard	Rubber	Soaps Detergents	Steam Electric Power Generation
Silver (Aq)	0.0007		0	0.2616	0		0.0297	0.0274
Arsenic (As)	0.001		2.659	0	0		0.0015	0.0899
Beryllium (Be)	0		0	0	0		0	0
Cadmium (Cd)	0.017		4.987	0.2834	0		0	0.0115
Total Chromium (Cr)	0.054		2.581	0.5014	0.0444		0.0063	0.0205
Copper (Cu)	0.280		265.961	0.4578	0.0444		0.0073	0.0399
Mercury (Hg)	0.001		0	0.0087	0		0.0011	0
Nickel (Ni)	0.011		60.944	0.02	0.0134		0.00284	0.0475
Lead (Pb)	0.036		77.572	0.2115	0.0987		0.02359	0.0525
Antimony (Sn)	0		0	0	0		0	0
Selenium (Se)	0		0	0	0		0	0
Thallium (Th)	0		0	0	0		0	0
Zinc (Zn)	0.201		169.55	0.3270	2.539		0.3571	0.2048
Cyanide (Cn)	0.096		0	0.2398	0.0233		0.0050	0.0227
Toxic Organics	134.783		0	1.548	0.705		0.1999	0
Pesticides	0		0	0	0		0	0
BOD	39.385		0	0	359.712		0	0
TSS	55.138		20501.16	0	543.095		0	32.47
Ammonia	0		0	0	0		0	0
Oil & Grease	0		199.471	0	0		0	0
Pretreatment Tech. Cost$/1000 gal.	$1.30		$59.00	--	$0.034		--	--

Table C3-V (Continued)

Industrial Wastewater Characteristics
(mg/l)

Pollutant	Textile	Timber	Non-categorical Industries
Silver (Aq)	0.0154	0	--
Arsenic (As)	0.0136	0.0014	--
Beryllium (Be)	0	0	--
Cadmium (Cd)	0.0016	0	--
Total Chromium (Cr)	0.1231	0.0384	--
Copper (Cu)	0.3079	0.0041	--
Mercury (Hg)	0.00019	0	--
Nickel (Ni)	0.0502	0.0007	--
Lead (Pb)	0.0308	0.0004	--
Antimony (Sn)	0	0	--
Selenium (Se)	0	0	--
Thallium (Th)	0	0	--
Zinc (Zn)	0.4051	0.2542	--
Cyanide (Cn)	0.0123	0	--
Toxic Organics	17.013	2.1583	--
Pesticides	0	-	--
BOD	307.862	110.312	1644
TSS	108.562	767.386	650
Ammonia	0	0	0
Oil & Grease	68.054	1.0551	0
Pretreatment Tech. Cost/$100 gal	$2.60	--	--

7. Data for non-categorical industries were included in the model, and were treated exactly as any other categorical industry. Industrial flow data and effluent characteristics were taken from a composite of various food industry subcategories studied by EPA, and account for much of the noncategorical industry flow. Hereafter, noncategorical industries will be considered one of the industry groups. This adjustment is necessary to account for the significant amount of industrial flow that does not contribute a substantial amount of priority pollutants.

8. The most accurate measure of an individual POTW's industrial flow was judged to be the flow reported in the Needs Survey. Therefore, the calculated industrial flow from Step 7 was adjusted or "normalized" to the reported flow by the following ratio:

where $IF_i = \frac{(RIF)_i}{(CIF)_i}$

IF = Industrial flow

RIF = Reported industrial flow (Needs Survey)

CIF = Calculated industrial flow

i = Categorical industry i

Where no industrial flow was reported on the Needs Survey, no adjustment was made unless the calculated industrial flow exceeded 50% of the total POTW flow. In that case, the reported total industrial flow was set equal to 25% of the POTW total flow (the median industrial flow of all plants reporting some industrial flow) and the individual categorical flows were adjusted accordingly).

The following is a measure of how the normalization procedure actually worked:

- At 50% of the POTWs the calculated industrial flow was lower than the reported flow; and subsequently the categorical industrial flows were adjusted upwards.

- At 19% of POTWs the calculated industrial flow was higher than the reported industrial flow; the categorical industrial flows were adjusted downwards.
- At 13% of the POTWs that did not report industrial flow, the calculated industrial flow was below 50% of the POTW flow and was unadjusted.
- At 6% of the POTWs that did not report industrial flow, the calculated industrial flow exceed 50% of the POTW flow and consequently was normalized to 25% of the POTW flow.
- At 12% POTWs that did not report industrial flow, the calculated industrial flow was also 0, and was not further adjusted.

Overall, these figures imply that the adjusted D&B counts and the EGD data resulted in slightly lower industrial flow projections than those actually reported by POTWs. This may have occurred because the reported industrial flows or the Needs Survey for some POTWs include commercial flows or industrial flows not covered by the SIC definitions for the 34 industries. However, the flow normalization schemes should account for these discrepancies.

9. A baseline concentration of toxic pollutants to account for domestic and commercial contribution was added to the industrial concentration from Step 8. The baseline concentration was calculated from two sources (the EPA 40 POTW Study and EPA 4 City Study). These data sources were described in Appendix C.2. A summary of these concentrations is presented in Table C3-VI.

10. The total mass of toxic pollutants was calculated from the industrial component (normalized industrial flow and EGD concentration) and domestic component (nonindustrial flow and baseline concentration). Where pretreatment options were in effect only the industrial component was considered controllable.

11. The removals that would be achieved by the pretreatment option to complete categorical standards were developed by EPA for each categorical industry, and were reported for all metal priority

TABLE C3-VI

Priorty Pollutant Baseline Concentrations

Pollutant	Concentration (mg/l)
Silver (Ag)	0.005
Arsenic (As)	0.003
Beryllium (Be)	0.0
Cadmium (Cd)	0.003
Total Chromium (Cr)	0.05
Copper (Cu)	0.061
Mercury (Hg)	0.0003
Nickel (Ni)	0.021
Lead (Pb)	0.049
Antimony (Sn)	0.001
Selenium (Se)	0.0
Thallium (Th)	0.0
Zinc (Zn)	0.175
Cyanide (Cn)	0.041
Total Metals	0.3683

pollutants and the total organic priority pollutants. Since not every industry has developed guidelines or effluent limitations, some of these removals were estimates of what technology similar to "BAT" would achieve. The removals used in the model for each industry for each pollutant are listed in the Table C3-VII.

12. The projected POTW influent was calculated by summing the total pollutant loading (Step 10) under the appropriate industrial pretreatment option and allocating this load to the total POTW flow. This projected influent concentration was displayed for each POTW on its summary sheet, and the average of all POTWs was displayed on the Model aggregate summary sheet. A discussion of these results and their meaning appears in Appendix C-4.

Calculation of Industrial Sludge Quantity and Quality

The pretreatment of industrial wastes has a wide variety of technologies available with highly variable costs and sludge generation rates. Because the actual technologies assumed were not available from the EGD data, some assumptions were necessary for this component of the model. Pretreatment technology costs were provided only as the national total cost. To be able to relate this figure to the "normalized" industrial flow (which adjusts the flow from each categorical industry but not the count of plants) the total national cost was divided by the total flow for that industry to arrive at a cost per gallon. This cost was used by the model to compute the cost for each category at each POTW. In reality, small IUs are likely to have a higher cost per gallon treated than large IUs. However, for POTWs that have a number of IUs in each category, the cost per gallon should be correct within a reasonable limit of error. The aggregated cost for pretreatment from the model will be compared to EGD predictions in Appendix C-4.

Sludge disposal rates for industrial pretreatment technologies also vary signficantly. Some neutralization and chemical treatment methods will generate several pounds of sludge for each pound of suspended solids removed while other technologies will generate substantially less. Since the

Table C3-VII

Level of Removal By Model POTW

	Removal in Percentage		
Pollutant	Primary Treatment	Secondary Treatment	Tertiary Treatment
Silver (Ag)	20	70	70
Arsenic (As)	0	0	0
Beryllium (Be)	0	0	0
Cadmium (Cd)	27	50	50
Total Chromium (Cr)	34	71	79
Copper (Cu)	19	82	82
Mercury (Hg)	12	51	63
Nickel (Ni)	17	32	39
Lead (Pb)	48	57	57
Antimony (Sn)	0	60	60
Selenium (Se)	0	0	0
Thallium (Th)	0	0	0
Zinc	31	76	79
Cyanide (Cn)	14	59	59
Toxic Organics	35	79	86
Pesticides	0	0	0

pretreatment technologies used were unknown, we assumed that two pounds of sludge would be generated for each pound of toxic metal removed, while TSS removed would generate sludge on a pound for pound basis. All industrial sludges from the categorical industries were assumed to be hazardous, with a disposal cost of $400 per ton of dry solids (including transportation).

The concentration of toxic pollutants in industrial sludges was also displayed by the model. These concentrations were computed by allocating the toxic pollutants removed by pretreatment to the total quantity of industrial sludge. The removals were the same as those described in C3-VII Step 11.

POTW MODULE

The majority of the POTW effluent quality, sludge quality, and receiving stream impacts are all based on the influent to the POTW. The influent for each POTW is a calculated average, as has been detailed. The remaining calculations in the POTW module include:

- POTW effluent quality
- Impact of POTW effluent on Stream Quality
- POTW sludge quantity/quality
- Emission of volatile toxic pollutants to the atmosphere
- Pretreatment program development and implementation costs.

POTW Effluent Quality

The POTW effluent quality was computed by applying an assumed removal for each pollutant to the influent concentration. This removal was developed from the EGD 40 POTW study, and was the median removal from all plants. Removals for tertiary plants were developed from 9 of the 40 POTWs where a variety of advanced waste treatment processes were sampled. Although the 40 POTW study collected samples of primary effluent at a number of secondary POTWs, this data was judged to be nonrepresentative of primary plants due to the influence of recycle lines. Primary effluent data was consequently based on one of the 40 POTWs in which the primary system was unaffected by recycle lines. For most pollutants primary treatment was estimated to achieve approximately 35%

removal. Secondary effluent generally removed 70-80% of most toxic pollutants while tertiary effluent removed 70-90%. The actual removal rates used in the model are indicated on Table C3-VII. The POTW effluent is displayed on each POTW's summary sheet, and is averaged for display on the aggregate output. The changes in effluent quality under various pretreatment options is one of the primary purposes of the model, and is discussed in the following section and in Appendix C-4.

Impact of POTW Effluent on Stream Quality

One of the measurements of pretreatment effectiveness is the net change in stream quality that would be achieved by a pretreatment strategy. The computer model developed data to assess these impacts by two methods:

1. The calculated incremental concentration change in the receiving stream contributed by the POTW.

2. The comparison of that incremental concentration to national water quality criteria.

3. The total quantity of toxic pollutants discharged under each pretreatment option.

The incremental concentration was computed by dividing the POTW effluent concentration by the dilution ratio for the receiving stream. The dilution ratio was defined as the upstream receiving water flow plus the POTW flow divided by the POTW flow. The stream flows used were the average flows obtained for STORET and USGS records. However, flows from only 703 streams identified from the 2000 POTWs were available at this writing. Therefore, data related to water quality were calculated on this reduced database and scaled up to represent the universe of POTWs. The number of POTWs with stream flows was further reduced because some of the 2000 POTWs were reported (by the Needs Survey) to have no flow and consequently were not used in the model. The final number of POTWs for which we identified both the POTW flow and the corresponding stream flow was 665. These POTWs formed the basis for calculating water quality impacts.

The most precise measure of how pretreatment will impact water quality is the net change in toxic pollutant concentration (and mass) in the receiving stream under various pretreatment options. The computer model indicates these figures on a plant-by-plant basis and as an average of all plants on the aggregation model. These results are evaluated in Appendix C-4.

Although the above net changes are fairly accurate measures of water quality impacts, they require interpretation to determine whether the concentrations of any one toxic pollutant are signficant. JRB approached this task by comparing these concentrations to:

- The national water quality criteria for aquatic life (chronic toxicity)
- recommended criteria for human health.

The values and references for these criteria are listed in Table C3-VIII. The results of the comparison are presented in Appendix C-4. Two limitations should be noted, however, on use of Federal water quality criteria. One is that these criteria are not standards, and only serve as a measurement tool. Secondly, many of these criteria values are sufficiently low that any assumed concentration of that pollutant will trigger exceedence in any POTW with a low or moderate dilution ratio. The term exceedence is used throughout this report to indicate a predicted water quality concentration in excess of the national water quality criteria. Specifically, the aquatic standard for cadmium is 25 ng/l. Cadmium cannot be measured at levels below 1 ug/l by conventional atomic absorption (AA) or inductively coupled arc plasma (ICAP) procedures. Therefore, the number of cadmium exceedences is not very sensitive to the level of pretreatment in place. This insensitivity to pretreatment extends to the human health criteria for arsenic and to the aquatic criteria for arsenic. Other pollutants which have higher (and measurable) criteria values are more sensitive to industrial pretreatment levels, although the overall number of exceedences is smaller. These results are discussed in Appendix C-4.

Table C3-VIII

Receiving Stream Water Quality Criteria

Pollutant	Freshwater Aquatic Life (ug/l)	Human Health Criteria (ug/l)
Silver (Aq)	0.12	50
Arsenic (As)	440	0.0022
Beryllium (Be)	5.3	0.037
Cadmium (Cd)	0.025	10
Total Chromium (Cr)	44	1700
Copper (Cu)	5.6	1000
Mercury (Hq)	0.2	0.144
Nickel (Ni)	96	13.4
Lead (Pb)	3.8	50
Antimony (Sn)	1600	146
Selenium (Se)	35	10
Thallium (Th)	40	13
Zinc (Zn)	47	5000
Cyanide (Cn)	3.5	200

POTW Sludge Quality/Quantity

Another major benefit of industrial pretreatment is the improvement in sludge quality that will result from such a program. The model assessed sludge quality improvement by predicting POTW sludge quality for each pretreatment option. POTW sludge quantity from domestic and commerical sources was predicted from literature sources as follows (1):

Primary Plants: Dry tons/day = 0.625 x POTW flow in MGD
Secondary Plants: Dry tons/day = 1.17 x POTW flow in MGD
Tertiary Plants: Dry tons/day = 1.39 x POTW flow in MGD

Sludge solids were then increased by the total solids contributed by industsources was predicted from literature sources as follows (1):

Primary Plants: Dry tons/day = 0.625 x POTW flow in MGD
Secondary Plants: Dry tons/day = 1.17 x POTW flow in MGD
Tertiary Plants: Dry tons/day = 1.39 x POTW flow in MGD

Sludge solids were then increased by the total solids contributed by industrial flow under the option in effect. Sludge quality was computed by distributing the toxic pollutants removed by the POTW into the total POTW sludge, on a dry weight basis. The removal rates used were the same as those presented in Table C3-VII. (Metcalf and Eddy, 1972.)

POTW sludge was assumed to always be non-hazardous and sludge disposal costs were based solely on the sludge disposal methods used by the POTW (from the Needs Survey). The following costs were applied to all municipal sludge:

Disposal Method	Assumed Cost
Ocean Dumping	$30/ton of dry solids
Land Spreading	$60/ton of dry solids
Landfill	$80/ton of dry solids
Incineration	$150/ton of dry solids

The costs include transportation, and were supplied by EPA's Office of Solid Waste. One important assumption implied in this data is that POTW sludge disposal costs are not affected by the level of toxic pollutants present. In actuality, some POTWs that have chosen an expensive disposal option, such as incineration, may have been driven inpart by sludge quality problems that prohibited less costly options such as application to cropland, (O'Farrell, 1981). The magnitude of this assumption will be discussed in Appendix C-4.

The sludge disposal method used by each POTW was obtained from the Needs Survey (Question 32). If a POTW did not indicate any disposal method, we assumed that landfilling was employed. The Needs Survey did not require POTWs that used multiple disposal methods to report the amount of sludge related to each method. Consequently, JRB assumed that POTWs using multiple disposal methods divided their sludge equally among them.

The assumption that POTW sludge disposal costs are not affected by toxic pollutant concentration has a serious impact on the entire cost benefit structure of the RIA. Throughout the RIA POTW sludges have been assumed to be non-hazardous while industrial pretreatment sludges have been assumed to be hazardous. The non-hazardous disposal costs are 3 to 11 time less expensive than hazardous costs, according to EPA estimates. Consequently, a unit of toxic pollutant removed by pretreatment at an industrial site incurs both the cost of removal by the treatment system and the cost of disposal as a hazardous waste. Under the option of no pretreatment, where the toxic pollutant is discharged to the POTW, no cost of industrial pretreatment is incurred, and dilution with domestic sludge permits its disposal as a non-hazardous waste and at much lower unit cost. There is no corresponding cost reported for the contamination of the POTW sludge. This assumption has a strong effect of skewing the cost benefit analysis towards the option of non pretreatment, in essence using the dilution effects of domestic sewage.

Emission of Volatile Priority Pollutants to the Atmosphere

One effect of the discharge of volatile priority pollutants to POTWs by industry is their volatilization and subsequent discharge to the atmosphere. The model does not assess the environmental effect of this, but reports the total mass discharge under each option. The assumptions for this calculation are:

- 90% of the toxic organics received by the POTW are volatile
- 80% of the volatile pollutants are removed by the POTW with 20% passing through
- 90% of the volatiles removed by POTW are released to the atmosphere.

Pretreatment Program Development and Implementation Costs

JRB developed two estimates of pretreatment program costs. The first based on engineering estimates by individuals experienced in developing pretreatment programs and the second based on a statistical analysis of costs reported by cities who have implemented programs. These two estimates are presented below:

1. Engineering Estimates of POTW Pretreatment Development and Implementation Cost

The following cost estimates have been developed based on an approach option for a POTW to control nondomestic discharges to the POTW system. This option meets the requirements of 40 CFR 403 and is also reasonable and functional at the local level. In developing these estimates, actual program experience was used and a number of assumptions have been made and will be presented below.

The POTW pretreatment program cost estimates developed cover two interrelated activities: Figure C3-2 - development of a local program; and Figure C3-3 - implementation of the local program. In both estimates, the size of the POTW was broken into 4 general size ranges. These size ranges were compared to 3 relative ranges of nondomestic dischargers to the POTW. Each nondomestic discharger range is comprised of a combination of categorical and noncategorical users.

FIGURE C3-2.

ESTIMATED POTW PRETREATMENT PROGRAM DEVELOPMENT COSTS

SIZE OF POTW / NUMBER OF IUs	IU < 5 Categorical Industries IU ≤ 10 Noncategorical Industries				> 5 IU ≤ 10 Categorical Industries IU ≤15 Noncategorical Industries				IU > 10 Categorical Industries IU > 15 Noncategorical Industries			
	Item	Labor	Non-Labor Costs		Item	Labor	Non-Labor Costs		Item	Labor	Non-Labor Costs	
POTW <5 MGD	1	1,429	100	1,529	1	1,429	100	1,529			$14,555	
	2	1,440	100	1,540	2	1,981	200	2,181				
	3	2,161	100	2,261	3	3,601	100	3,701				
	4	2,744	400	3,144	4	2,744	400	3,144				
	5	-	4,000	4,000	5	-	4,000	4,000				
	6			12,474	6			14,555				
≥ 5 MGD POTW <25 MGD	1	1,715	200	1,915	1	1,715	200	1,915	1	1,715	200	1,915
	2	2,340	300	2,640	2	2,809	300	3,109	2	4,141	1,200	5,341
	3	2,161	200	2,361	3	3,601	200	3,801	3	7,202	200	7,402
	4	6,064	800	6,864	4	6,064	800	6,864	4	6,064	800	6,864
	5	-	4,000	4,000	5	-	4,000	4,000	5	-	8,000	8,000
	6			17,780	6			19,689	6			29,522
≥25 MGD POTW <50 MGD	1	2,858	300	3,158	1	2,858	300	3,158	1	2,858	300	3,158
	2	3,781	400	4,181	2	4,321	800	5,121	2	5,582	1,600	7,182
	3	2,161	200	2,361	3	3,601	200	3,801	3	7,202	200	7,402
	4	15,216	1,000	16,216	4	15,216	1,000	16,216	4	15,216	1,000	16,216
	5	-	4,000	4,000	5	-	26,000	26,000	5	-	30,000	30,000
	6			29,916	6			54,296	6			63,958
POTW ≥ 50 MGD	1	3,573	400	3,973	1	3,573	400	3,973	1	3,573	400	3,973
	2	3,200	800	4,000	2	3,600	1,600	5,200	2	4,300	3,200	7,500
	3	1,200	200	1,400	3	2,900	200	3,100	3	4,000	200	4,200
	4	11,760	1,200	12,960	4	11,760	1,200	12,960	4	11,760	1,200	12,960
	5	-	26,000	26,000	5	-	26,000	26,000	5	-	30,000	30,000
	6			48,333	6			51,233	6			58,633

NOTE: 1 - Legal 2 - IWS 3 - Engineering 4 - Administration/Program Submission 5 - Equipment 6 - Total

FIGURE C3-3.

ESTIMATED POTW PRETREATMENT PROGRAM IMPLEMENTATION COSTS

NUMBER OF IUs / SIZE OF POTW	IU ≤ 5 Categorical Industries IU ≤ 10 Noncategorical Industries				> 5 IU ≤10 Categorical Industries IU ≤15 Noncategorical Industries				IU > 10 Categorical Industries IU > 15 Noncategorical Industries			
	Item	Labor	Non-Labor Costs		Item	Labor	Non-Labor Costs		Item	Labor	Non-Labor Costs	
POTW < 5 MGD	1	300	100	400	1	300	-	300				
	2	4,800	5,500	10,300	2	10,080	10,300	20,380			$36,139	
	3	620	100	720	3	1,143	100	1,243				
	4	7,680	100	7,780	4	14,016	200	14,216				
	5			19,200	5			36,139				
≥5 MGD POTW <25 MGD	1	450	100	550	1	450	100	550	1	450	100	500
	2	4,800	5,500	10,300	2	10,080	10,300	20,380	2	12,000	12,500	24,500
	3	3,456	100	3,556	3	3,456	100	3,556	3	6,912	100	7,012
	4	7,680	100	7,780	4	14,016	200	14,216	4	14,400	400	14,800
	5			22,186	5			38,702	5			46,862
≥25 MGD POTW <50 MGD	1	600	100	700	1	600	100	700	1	600	100	700
	2	4,800	5,500	10,300	2	10,080	10,300	20,380	2	12,000	12,500	24,500
	3	6,912	100	7,012	3	10,368	100	10,468	3	13,824	100	13,924
	4	7,680	100	7,780	4	14,016	200	14,216	4	14,400	400	14,800
	5			25,792	5			45,764	5			53,924
POTW ≥ 50 MGD	1	750	100	850	1	750	100	850	1	750	100	850
	2	2,560	5,500	8,060	2	5,376	10,300	15,676	2	8,000	12,500	20,500
	3	7,680	200	7,880	3	9,600	300	9,900	3	11,520	400	11,920
	4	4,800	100	4,900	4	10,080	200	10,280	4	12,000	400	12,400
	5			21,690	5			36,706	5			45,670

NOTE: 1 - Legal   2 - Monitoring and Surveillance   3 - Engineering   4 - Administration/Reports   5 - Total

Major cost items include labor and nonlabor line items. Labor costs include: legal, engineering, field and laboratory, and arrangement and administration. Nonlabor costs include: equipment purchase, postage, duplicating, notices, etc. The assumptions used to develop these cost estimates are as follows.

General Assumptions:

These general assumptions are applicable to the development of both cost estimates.

- Every POTW and their respective consultant has available for their use and review all of the pretreatment program guidance documents prepared under the OWE contract, (i.e., 304 (g) Guidance Document, Industrial Residuals Manual, Procedures Manual, etc.)
- The Cost Estimates were developed for the normal type of POTW/IU situation and are not intended to be directly applicable to the very large or special POTWs (i.e., Chicago - MSD, Detroit, Los Angeles, Passiac Valley (NJ), Chattanooga, etc.)
- Development costs are based on getting a reasonable program started and during implementation the program can be fine tuned and expanded as required. This trend is indicated by the deflated development costs with somewhat higher than expected operating costs.
- 95% of all the POTWs in the U.S. are 10 MGD or less.
- Approximately 90-95% of all POTW programs will fall within the first two POTW ranges and the first two IU ranges.
- Labor Costs are estimated assuming that POTWs up to 50 MGD will use consultants and POTWs greater than 50 MGD will use in-house capabilities. The following rates were used and include overhead, fringe benefits, etc.:
- Legal - Applies to all POTWs
  - \$42,000 per year = approx. \$20/hour
- Consultants (Overhead 1.5)
  - Engineering - \$75,000/year = approx. \$36/hour
  - Field Crews - \$34,000/year = approx. \$30/hour
  - Laboratory - \$62,500/year = approx. \$30/hour
  - Admin/Mgmt - \$75,000/year = approx. \$36/hour
- POTW (Overhead 0.33)
  - Engineering - \$40,000/year = approx. \$20/hour
  - Field Crews - \$34,000/year = approx. \$16/hour

- o Laboratory - $34,000/year = approx. $16/hour
- o Admin/Mgmt - $40,000/year = approx. $20/hour

o For POTWs < 5 MGD and within IU > 10 category, use previously developed costs in row.

Development Assumptions:

These assumptions are applicable to the cost estimates for developing local POTW pretreatment programs.

1. Legal Costs. Items here include: ordinance review, comparison with the EPA Model Ordinance, drafting of modified POTW legal authority, attending City Council meetings, etc. The costs presented are based on the assumption that a single jurisdiction is involved. If inter-jurisdictional questions have to be resolved, then legal costs could be multiplied by a factor of 2.0 to 2.5.

2. Industrial (Nondomestic) Waste Surveys (IWS). IWS are assumed to be updated by using as much of the existing data as possible and performing a paper survey with none or limited sampling and analytical efforts. The idea is to frame the program in and then fine tune it as the monitoring and surveillance activities are implemented.

   The development costs included looking at potentially significant noncategorical industries as well as the categorical industries. A limited number of users will be looked at via a waste questionnaire with a fewer number actually being involved in the monitoring and surveillance program to be implemented.

   The cost estimate includes hours based on POTW size to create the general user list and 3 hours per IU for the questionnaire.

   The cost estimates are based on single service areas and if jurisdictional conditions exist, the costs could be multiplied by a factor of 1.5 to 2.0.

3. Engineering. This item is to include: technical input into the ordinance review, standard setting, reviewing industrial compliance schedules, etc. The cost estimate assumes that engineering is primarily a function of the number of significant nondomestic dischargers into the POTW with less impact due to size of the POTW. Estimates were based on 8 hours per average number of IUs.

4. Administration/Program Submission. This item was assumed to be a function of POTW size and complexity rather than number of users. The activities include: treatment plant overview, development of procedures, public participating, legal coordination, funding procedures, and assembly of the submission packet. Nonlabor costs include: printing, public notices, etc. In addition, POTW rates were used to develop contract services.

5. Equipment. It is assumed that justified field and laboratory equipment is included as a development cost. The laboratory cost only includes the purchase of an AA ($22,000) for POTWs between 25-50 MGD with more than 5 categorical industries and all POTWs greater than 50 MGD. Field equipment (including safety) was estimated to be $4,000 for all POTWs up to 10 categorical industries and $8,000 for all POTWs with more than 10 categorical industries. It is also assumed that organic analysis is not required.

Implementation Assumptions:

These assumptions apply to the cost estimate for implementing a local POTW pretreatment program.

1. Legal costs. Minimal legal costs are assumed as the normal operating needs of a local program. Enforcement costs are assumed to be picked up by fines and penalties levied on the IU in noncompliance.

2. Monitoring/Surveillance. It is assumed that smaller POTWs use in-house efforts to collect samples and use contract or regional laboratories to perform analysis. Demand monitoring and additional sampling/analytical costs are to be recovered from the IU in noncompliance and not assumed to be normal operating costs.

   Laboratory costs for categorical industries are assumed to be related to assuring validity of self-monitoring reports. Costs are based on $400 per sample and approximately 2 random samplings per industry per year. Laboratory costs for noncategorical industries are based on $150 per sample with approximately 2 samples taken per year. Field crew costs are based on 2 men per sampling event, spending 4 hours per industrial user, twice a year. IUs were averaged to represent a reasonable spread across industrial user ranges.

3. Engineering. Nominal engineering costs were assumed for the norm. Review of new industry coming into town is hard to predict and is considered as an add-on. Engineering efforts are used to update and fine tune the local program. A range of effort from 1 day per quarter for the small POTWs up to 6 days per month for the large POTW with a heavy IU base was used.

4. Administration/Reports. These activities are assumed to include review and quality assurance that the POTW program complies with the resousibilities detailed in the program submiss[illegible] Approximately 8 hours per IU per sample per year was used as an estimate where consultant efforts were used and 12 hours per IU per sample per year was used as an estimate for POTWs 50 MGD. In addition, where consultants were used, an additional 8 hours per month of POTW administrative effort was included to cover contract management. Nonlabor costs include: filing, duplicating, postage, etc.

Statistical Analysis of Reported Local Pretreatment Program Costs

Regression analysis is one method of developing a quantitative model to aid in predicting the cost associated with local pretreatment programs. For the purposes of this analysis, the quantitive model generated relates changes in the development and operating costs of a pretreatment program to the size and level of industrial activity at the treatment facility.

Equations of the following form were estimated and tested for statistical significance:

$$C = a + B_1x_1 + b_2x_2 + b_3x_3 + e$$

where

c = dependent variable, pretreatment program development and operating cost

b_1, b_2 + b_3 = the parameters of the relationship to be estimated

x_1, x_2 + x_3 = explanatory variables, i.e., size and industrial activity

a = constant term

e = error term.

The explanatory variable size is defined in this analysis as the actual flow of wastewater entering the treatment facility in millions of gallons per day (mgd). The measure of industrial activity at the treatment facility includes such variables as the percent of actual wastewater flow from industrial sources, the number of industrial users serviced by a given POTW, and the number of electroplaters and metal finishers discharging to a treatment facility.

These explanatory variables were selected because they relate to the most costly elements of development and operating a pretreatment program, i.e., industrial user survey, sampling and analysis, and manpower requirements. These elements appear to be heavily influenced by the facility size and the level of industrial activity at the facility. As the size/flow of a POTW increases, it is likely to require additional manpower to maintain a workable pretreatment program. Similarly, higher levels of industrial activity are liable to necessitate an increased level of effort in the the industrial survey, and additional sampling and analysis requirements.

The regression analysis tests the strength of these relationships. If a signficant portion of the fluctuation in the dependent variable can be accounted for by the explanatory variables, then the resulting equation can be used to predict pretreatment program costs to a given POTW.

Data Collection and Limitations

The basic sources of data for estimating the above variables are:

- phone contacts with POTW Industrial Waste Coordinators
- pretreatment programs submitted to EPA Headquarters for review and approval
- 201 Construction Grant requests to fund the development cost of pretreatment programs
- Needs Survey containing information on total and industrial flow at various POTWs
- Dun & Bradstreet tapes listing the number of industrial users by SIC code serviced at various POTWs.

Separate regression analyses are performed for the development and operating costs. Only 14 observations are included in the operating cost analysis due to the limited number of POTWs currently operating pretreatment programs. Although this number is small, the wide range provided by the individual data points strengthens the analysis.

Of the 14 POTWs in the operating cost analysis, eleven are currently operating pretreatment programs. Of these eleven POTWs, two have received EPA approval, four are currently awaiting EPA approval, and five are at various stages of the review process. The operating cost figures were obtained primarily from phone contacts with the POTW Industrial Waste Division, while data on the explanatory variables were taken from the Needs Survey and Dun & Bradstreet tapes.

The pretreatment program development cost analysis is based on a total of 54 observations. The development cost information was extracted from various POTW construction grant applications provided by EPA regional pretreatment coordinators. The data for the explanatory variables were derived from the Needs Survey and Dun & Bradstreet tapes and then matched with the POTW grant requests.

Only POTWs with an actual flow of less than 150 mgd are included in the development cost analysis. This cutoff point was chosen because the costs observed for large (> 150 mgd) POTW pretreatment programs were considered to be heavily dependent on specific site factors. Inclusion of these outliers would exert upward pressure on the regression results and therefore introduce a distinct bias on the smaller plants in the model. The development cost for large POTWs (> 150 mgd) is estimated on a case-by-case basis and is presented in Section III of the report. In an attempt to identify a spectrum for development costs, individual regressions were performed for the states of New Jersey and California.

Results

A number of regression analyses were performed in an attempt to account for the fluctuation in the development and operating cost data in the sample POTW population. These regression results are presented in Tables C3-IX through C3-XI. The separate analyses conducted for the development and operating costs are discussed in the following two sections.

Development Cost Model

After testing several functional forms and different explanatory variables, Equation 8 in Table C3-IX was selected for use as the pretreatment development cost predictor. In this equation, both the actual flow in mgd and the constant term are statistically signficant. The explanatory variable measuring the percent flow from industrial sources is of questionable significance. This equation was selected as a predictor of development cost to avoid data inconsistencies. All of the other equations required a mix of data bases and therefore lowered confidence in those equations as predictors. The logarithmic functional form was selected under the assumption that the size of POTWs is logarithmically distributed.

TABLE C3-IX DEVELOPMENT COST REGRESSION EQUATIONS

Equation Number	Dependent Variable	Functional Form	Actual Flow (mgd)	% Industrial Flow	% Electroplaters & Metal Finishers	Number of Industrial Users	Number of Electroplaters & Metal Finishers	Constant	Degrees of Freedom	Coefficient of Determination R^2	Standard Error
1	Development $'s (000)	linear	2.51 (2.39)			- .51 (-1.77)	9.23 (2.49	49.84 (2.46)	53	.41	121.5
2	Development $'s (000)	log	.54 (4.71)			- .064 (- .38)	.003 (.02)	3.18 (6.65)	53	.41	.87
3	Development $'s (000)	linear	2.61 (2.43)	.976 (1.13)	-2.29 (- .58)	- .59 (-1.82)	10.39 (2.50)	41.03 (1.21)	53	.43	121.6
4	Development $'s (000)	log	.51 (4.25)	.097 (1.08)	.104 (.61)	- .003 (.02)	- .009 (- .44)	2.75 (4.47)	53	.43	.87
5	Development $'s (000)	linear	2.55 (2.32)			.158 (1.41)		41.75 (1.99)	53	.34	127.5
6	Development $'s (000)	log	.54 (4.79)			- .062 (- .54)		3.18 (8.77)	53	.42	.86
7	Development $'s (000)	linear	3.75 (5.02)	.66 (.82)				34.9 (1.37)	57	.31	127.99
8	Development $'s (000)	log	.409 (6.02)	.083 (1.05)				2.91 (12.43)	57	.42	.85

TABLE [illegible]-X REGIONAL DEVELOPMENT COST REGRESSION EQUATIONS

Equation Number	Dependent Variable	Functional Form	Actual Flow (mgd)	% Industrial Flow	% Electroplaters & Metal Finishers	Number of Industrial Users	Number of Electroplaters & Metal Finishers	Constant	Degrees of Freedom	Coefficient of Determination R^2	Standard Error
1 (Calif.)	Development $'s (000)	linear	6.16 (10.96)	-2.16 (-1.80)	-3.97 (-1.18)			32.96 (1.06)	12	.93	61.2
2 (Calif.)	Development $'s (000)	log	.79 (4.36)	- .062 (- .39)	- .053) (- .23)			2.33 (4.80)	12	.72	.71
3 (N.J.)	Development $'s (000)	linear	1.20 (.54)	6.60 (1.38)	1.08 (.12)			51.69 (.4)	11	.21	193
4 (N.J.)	Development $'s (000)	log	.26 (1.06)	.43 (2.01)	.07 (.25)			3.02 (3.94)	11	.48	.86
5 (Calif.)	Development $'s (000)	linear	2.59 (1.23)			.32 (3.17)		- 8.56 (- .50)	12	.94	51.8
6 (Calif.)	Development $'s (000)	log	.72 (3.39)			.06 (.24)		2.03 (2.18)	12	.71	.68
7 (N.J.)	Development $'s (000)	linear	1.57 (.81)			1.38 (2.06)		4.87 (.58)	11	.33	167.4
8 (N.J.)	Development $'s (000)	log	.27 (1.11)			.36 (1.73)		2.77 (3.34)	11	.41	.87
9 (Calif.)	Development $'s (000)	linear	3.55 (2.60)				2.74 (1.90)	-12.3 (- .60)	12	.92	62.4
10 (Calif.)	Development $'s (000)	log	.77 (4.16)				- .022 (- .14	2.23 (5.94)	12	.71	.68
11 (N.J.)	Development $'s (000)	linear	1.57 (.87)				18.1 (2.28)	53.25 (.68)	11	.38	161
12 (N.J.)	Development $'s (000)	log	.32 (1.27)				.296 (1.23)	3.61 (5.32)	11	.33	.93
13 (Calif.)	Development $'s (000)	linear	6.21 (10.32)	-2.95 (-2.22)				15.21 (.57)	9	.93	64.3
14 (Calif.)	Development $'s (000)	log	.80 (3.37)	- .068 (- .31)				2.27 (4.52)	9	.67	.81
15 (N.J.)	Development $'s (000)	linear	1.58 (.85)	6.32 (1.59)				51.6 (.02)	14	.21	169.5
16 (N.J.)	Development $'s (000)	log	.014 (1.34)	- .04 (1.32)				3.82 (8.43)	14	.29	.94

TABLE C3-XI ANNUAL OPERATING COST REGRESSION EQUATIONS

Equation Number	Dependent Variable	Functional Form	Actual Flow (mgd)	% Industrial Flow	% Electroplaters & Metal Finishers	Number of Industrial Users	Number of Electroplaters & Metal Finishers	Constant	Degrees of Freedom	Coefficient of Determination R^2	Standard Error
1	Operating $'s (000)	linear	2.04 (3.99)	2.38 (.49)				-53.12 (- .27)	13	.60	295.9
2	Operating $'s (000)	log	.499 (5.19)	.126 (.56)				2.87 (3.41)	13	.71	.535
3	Operating $'s (000)	log-linear	.005 (5.37)	.007 (.83)				4.44 (12.62)	13	.70	.521

Entering the actual flow (mgd) and the percent of that flow from industrial sources for a given POTW into Equation 8, will yield an estimate of the cost of developing a pretreatment program at that POTW. Figure C3-4 presents the estimated cost for a slected portion of the sample POTWs plotted against plant size. For example, a POTW receiving 45.2 mgd, 44 percent of which is from industrial users, will incur an estimated $162,000 in pretreatment development costs.

In addition to estimating a development cost equation for all 58 sample POTWs, similar regressions were performed separately for those POTWs located in New Jersey and California. The resulting equations are presented in Table C3-X. For the reasons noted above, and in order to maintain consistency between models, Equations 14 and 16 were selected as development cost predictors. These States were singled out under the assumption that the State of California is currently under more stringent State requirements and will yield more conservative cost estimates than the more loosely controlled state of New Jersey. The result of this regional analysis is presented in Figure C3-5. These State regression lines appear to confirm this assumption and provide an upper and lower bounding estimate of pretreatment development costs based on actual flow and percent of industrial flow.

Operating Costs

The fluctuation observed in annual POTW pretreatment program operating cost was regressed against actual flow and percent industrial flow. The results of these equations are presented in Table C3-XI. Equation 2 was selected as a predictor of POTW operating costs based on the strength of the coefficient of determination (R2). This coefficient shows 71 percent of the observed fluctuation in operating cost explained by Equation 2. Both the constant term and the explanatory variable size (actual flow, mgd) are statistically significant.

Figure C3-6 presents these operating cost estimates plotted against plant size. For example, a POTW with an actual flow rate of 156 mgd, with 11 percent flow from industrial sources, will incur $301,000 annually in pretreatment operating expenses.

FIGURE C3-4.

DEVELOPMENT COST ESTIMATES

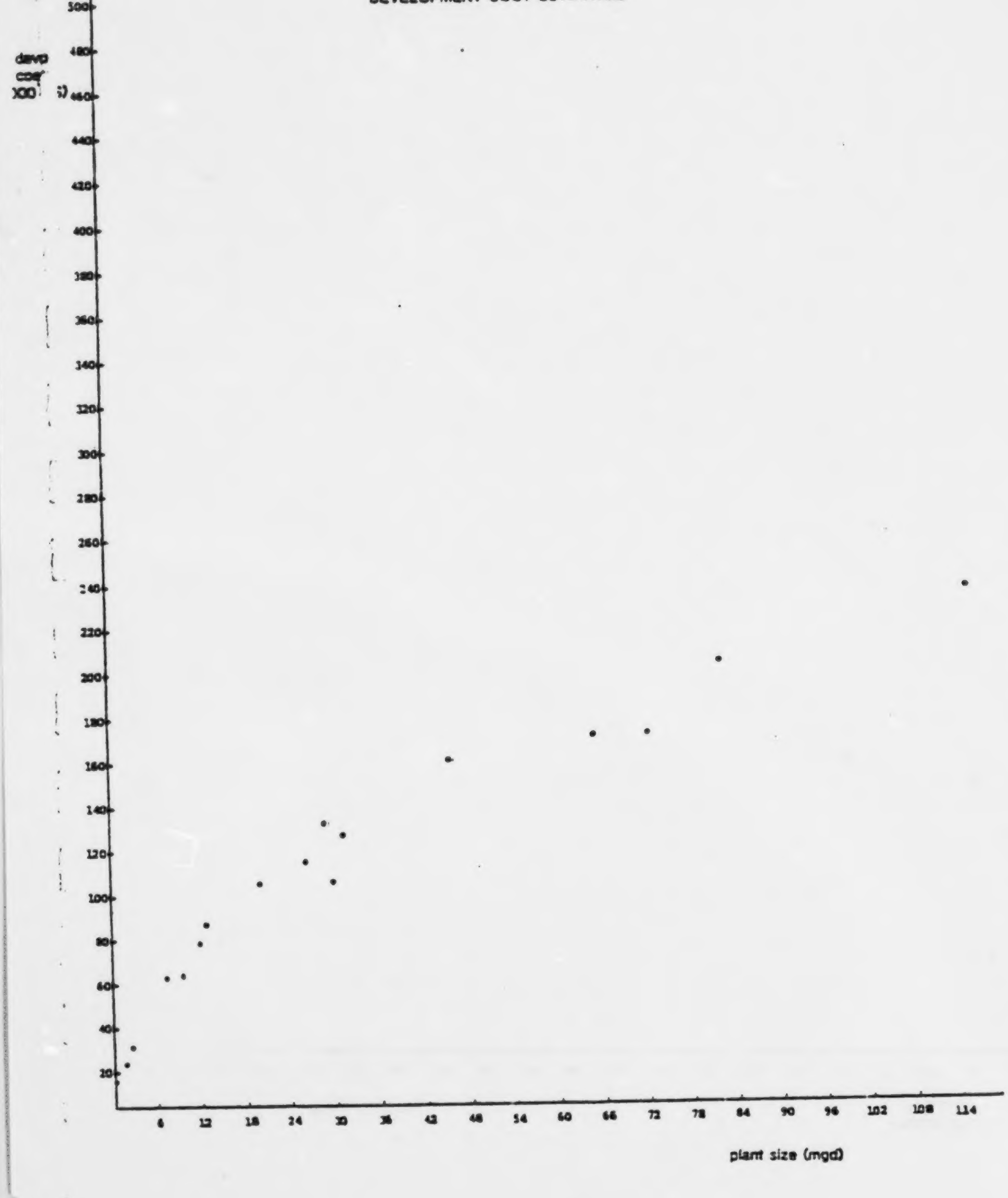


FIGURE C3-5.
REGIONAL DEVELOPMENT COST ESTIMATES

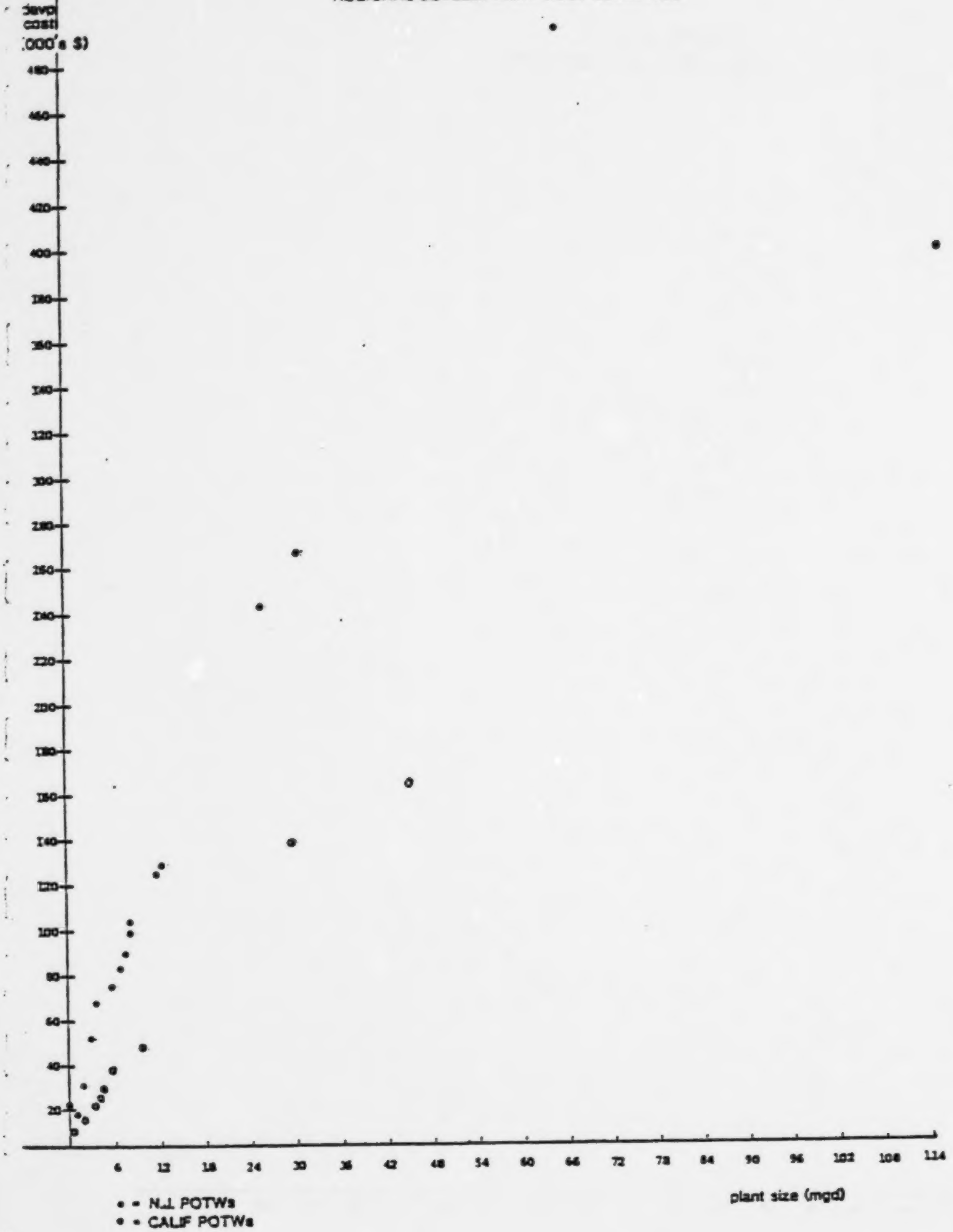
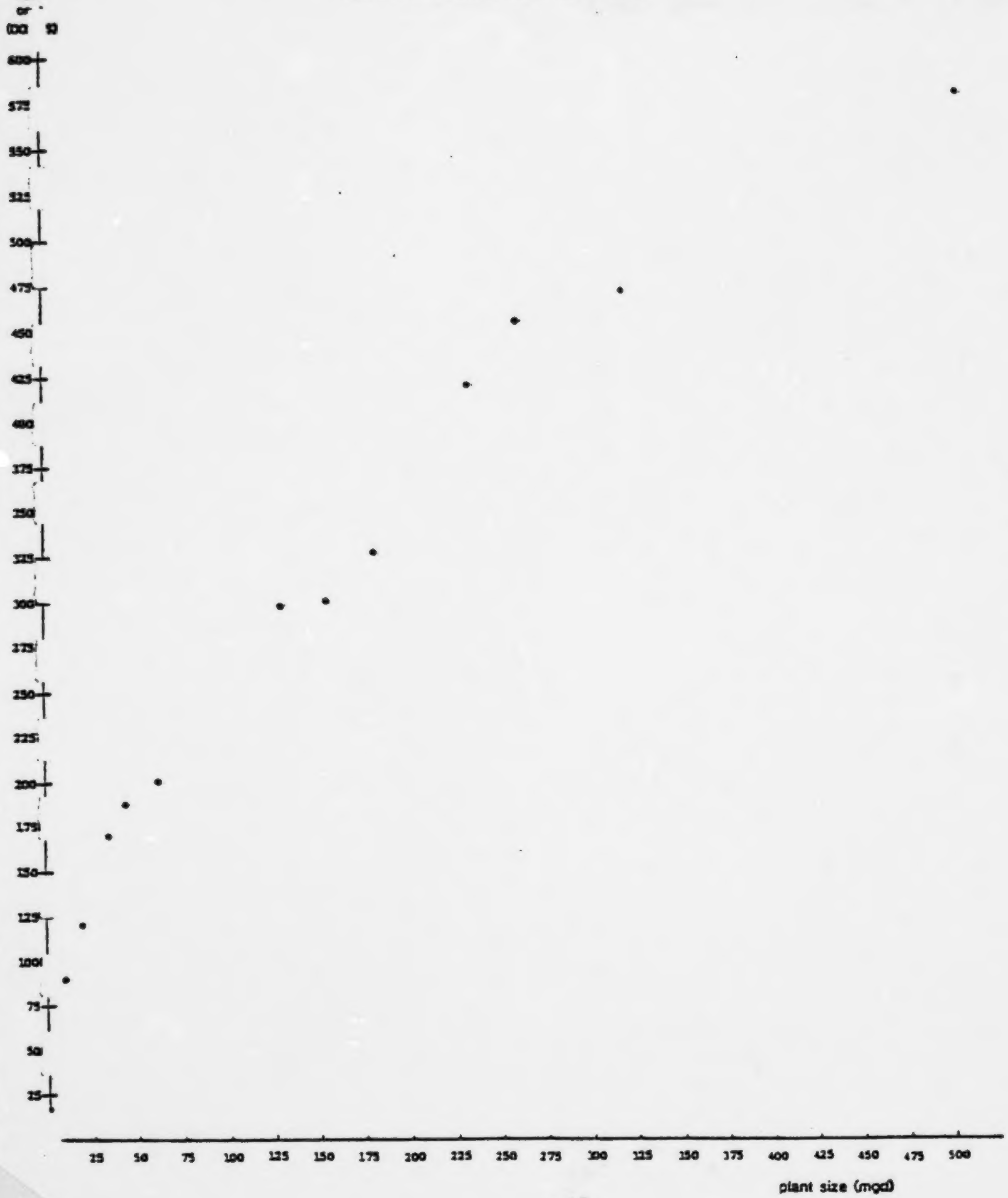


FIGURE C3-6.

ANNUAL OPERATING COST ESTIMATES



To provide an upper and lower bound estimate of annual operating costs, a 95 percent confidence interval analysis was conducted for Equation 2. The results of this confidence interval are presented in Figure C3-7. The black line represents the annual operating cost estimates obtained from Equation 2, the green line indicates the 95 percent upper bound limit, and the red line shows the 95 percent lower bound limits.

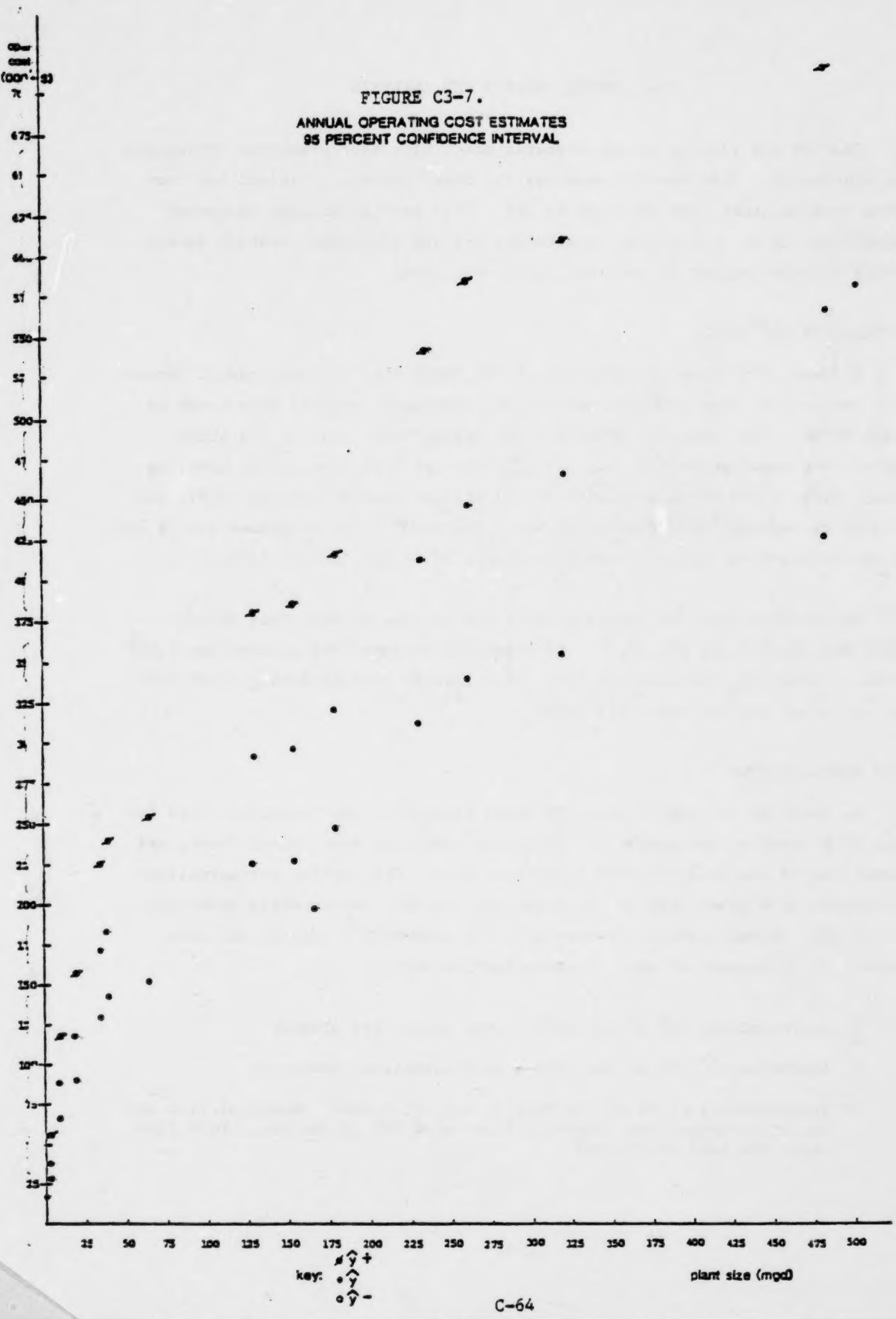


FIGURE C3-7.

ANNUAL OPERATING COST ESTIMATES
95 PERCENT CONFIDENCE INTERVAL

C-4. MODEL OUTPUTS AND ANALYSIS

Some of the results of the computer model have been presented throughout the RIA Report. This section presents the model outputs in detail and compares them to other data obtained by EPA. This section follows the model methodology as it is outlined in Appendix C-2 and discusses relative sensitivity of model output to various input conditions.

COVERAGE OF THE MODEL

EPA has identified approximately 2,000 POTWs that are required to implement the General Pretreatment Regulations. The model outputs were based on 1,839 POTWs. The remaining POTWs did not report their flow on the NEEDS Survey, and descriptive data was insufficient for inclusion in the modeling runs. These 1,839 POTWs accounted for 19 billion gallons per day (BGD), out of a total national POTW flow of 26 BGD. The 1,839 POTWs accounted for 38 BGD of industrial flow, out of a projected total of 44 BGD for the nation.

Stream flow data was only available for the two primary data sources (USGS and STORET) for 703 POTWs. Of these 703 streams, 665 matched the 1,839 POTWs. Therefore, the modeling runs reflect water quality data for 665 POTWs and all other outputs for 1,839 POTWs.

FLOW NORMALIZATION

As detailed in Section C-3, the model calculates the industrial flow for each POTW based on the number of industrial users and model plant flows, and normalizes to the reported POTW industrial flow. The initial pre-normalized industrial flow calculated by the model was 3.4 BDG, subsequently normalized to 3.8 BGD. Normalization, however adjusted some POTW's upwards and some downwards. A measure of how the normalization worked:

- Approximately 50% of the POTW's were normalized upwards
- Approximately 20% of the POTW's were normalized downwards
- Approximately 12.5% of the POTW's, did not report industrial flow and had a pre-normalized indusrial flow below 50% of the total POTW flow, which was used unadjusted

- o Approximately 5% of the POTW's did not report industrial flow and had pre-normalized industrial flow above 50% of the total POTW flow, which was adjusted downward to 25% of the total flow

- o Approximately 12.5% of the POTW's did not report industrial flow and also had no calculated industrial flow. These POTW's were left unadjusted.

This final group of POTW's represents on measure of the magnitude of error either in the model or the selection of the POTW's required to install pretreatment programs. In theory, virtually all of the POTW's covered by the General Pretreatment Regulations should have some industrial flow.

INDUSTRIAL SLUDGE QUANTITY/QUALITY

The model projects that under full categorical standards, industries would remove approximately 25,000 meric tons per year of toxic metals and 70,000 metric tons per year of toxic organic pollutants, which would accumulate in their sludge. The EGD (Effluent Guidelines Division) of EPA has calculated that categorical industries generate 28,000 and 95,000 metric tons per year of toxic metals and toxic organics per year respectively.

These numbers should compare well, because the EGD data was the basis for the model plant characteristics which formed the basis for the model's projections. Differences occur because the total EGD numbers were broken into pounds per IU, which were adjusted, and flow normalized at the POTW level prior to aggregation back to the total.

Industrial Sludge Quality is simply the total pounds of toxic materials applied to an assumed total sludge quantity. There are no meaningful measurements for comparison of these outputs.

POTW SLUDGE QUANTITY/QUALITY

The model predicts the POTW sludge quality under the options of no pretreatment in effect and under full categorical standards. These measurements can be compared to a variety of independently measured results, such as the 40 POTW study and various case studies. For example, a comparison between partial data from the 40 POTW Study (Table 3-5) and the model output, under the option of no pretreatment beyond what is in place today compares as follows:

40 POTW Study (9 POTW's)
mg/kg

Parameter	Average	Median	Model Average
Cadmium	157	14	26
Chromium	730	422	831
Copper	894	553	563
Nickel	240	121	181
Zinc	2874	2167	923

Overall, the comparison between the two methods is good. The data from Table 3-5, however is based on only the first nine POTW's. When the average data for all 40 POTW's is available a more definitive comparison should be available.

Another comparison between the model's projections and another independent measurement is the net change in sludge quality between the options of no additional pretreatment and full categorical standards. The raw data for this comparison has been presented in Table 3-7, which is repeated on the following page. The model's projections are compared against those case studies where sludge measurements were available. Overall, the model is extremely close to the actual measurements for every parameter except lead. The model probably predicts a higher nonindustrial baseline concentration of lead. The model probably predicts a higher non-industrial baseline concentration of lead than was experienced in those cities used as case-studies.

POTW INFLUENT QUALITY

The calculation of a POTW influent may be the single most important model output, because it forms the basis for prdicting the POTW effluent concentration (and water quality effects), the amount of organic priority pollutants volatilized (and air pollution effects) and the POTW sludge quality. The influent is calculated by the model according to the procedure in Appendix C-2, but is primarily based on the count of industries present in each POTW city, the EGD characteristics for that industry mix and the flow normalization according to the Needs Survey. The model predicts the following as the average influent for all 1839 POTW'S under the current in-place pretreatment scenario.

Parameter	Average Concentration (ug/l)(ug/l)
Silver	15
Arsenic	6
Cadmium	16
Chromium	468
Copper	252
Mercury	0.9
Nickel	203
Lead	75
Antimony	1
Zinc	410
Total Metals	1450
Total Organics	1820

Consistent with previous EGD data on metal finisher and other industries, chromium, copper, lead, nickel and zinc account for almost all of the total metals.

Several EPA studies in recent years have collected information on toxic pollutant concentrations in POTW influents. The most exhaustive study was the 40 POTW study, described in Appendix B-4 and C-2. On average the model compares well with that study. The 40 POTW study measured an average total metal concentration of approximately 1.5 mg/l (compared to 1.4 mg/l) for the model and a total toxic organic pollutant concentration of approximately 2 ug/l (compared to 1.8 for the model).

Under the option of full categorical standards the POTW influent toxic pollutant concentration drops substantially. The following table presents this data.

Parameter	Average Concentration (ug/l)
Silver	14
Arsenic	4
Cadmium	12
Chromium	89
Copper	103
Mercury	0.6
Nickel	52
Lead	60
Antimony	1.0
Zinc	210
Total Metals	546
Toxic Organics	550

One very significant coincident can be noted between the model outputs and without pretreatment. Several of the parameters that are least controlled by categorical standards have the lowest water quality criteria, and cause the majority of violations. As an example, cadmium is projected by the model to decrease 25% (from 16 ug/l to 12 ug/l) in the POTW influent by the imposition of categorical standards. This is a fairly small decrease, considering the criteria value of 25 ng/l. Copper, which has a smaller number of initial exceedences, is projected to decrease in POTW influent by 59% (from 252 ug/l to 103 ug/l) under categorical standards, compared to its criteria value of 5.6 ug/l. Arsenic and silver, which also have a high number of initial exceedences are also not as sensitive (33% and 6% reductions, respectively) to pretreatments as other parameters. Chromium (81%), Nickel (75%), and toxic organics (70%) are the pollutants most effectively reduced by categorical standards. However, chromium and nickel have fairly high criteria values, while no criteria exist for toxic organics as a group. These data anamolies have an important effect on the failure of exceedences to show a significant impact on the effects of categorical standards.

POTW REMOVAL EFFICIENCY

The use of median POTW removal efficiencies from the 40 POTW study was discussed in Appendix C-3, and the removal efficiencies used were indicatd in Table C3-VII. The use of median removals based on well operated POTW's may understate the number of exceedences by POTW's. Median removals will also have an equalizing effect on all POTW streams, and remove the normal degree of variation expected. Consequently, the number of initial exceedences by POTW's is slightly sensitive to the removal levels used, but the difference in exceedences between different pretreatment options is not particularly sensitive to the removal efficiency chosen.

POTW EFFLUENT RESULTS

The computation of the POTW effluent is straightforward calculation of reducing the POTW influent by the appropriate removal efficiency (depending on POTW level of treatment). The two previous tables listing influent concentration were reduced by the removal efficiencies as found in Appendix C-2 (see also Feiler, 1980 and Southworth 1980). The results are indicated below:

Parameter	Effluent Concentration Current Conditions (ug/l)	Effluent Concentration Categorical Standards (ug/l)
Silver	5.6	5.3
Arsenic	5.6	3.8
Cadmium	8.8	6.5
Chromium	170	32
Copper	66	28
Mercury	0.5	0.3
Nickel	141	36
Lead	33	27
Antimony	0.5	0.5
Zinc	123	65
Total Metals	554	204
Toxic Organics	507	154

Clearly since removal efficiencies are constant, influent and effluent concentration change proportionately.

EMISSION OF VOLATILE PRIORITY POLLUTANTS TO THE ATMOSPHERE

As indicated in Appendix C-3, a rough estimate of emissions of volatile pollutants was made based on assumptions derived from the 40 POTW study. The model projects that approximately 50,000 tons/year of organic pollutants volatilize from the 1839 POTW's included. The model does not account for any volatilization in the POTW collection system, and to our knowledge no large scale study of this phenomenon has been completed by EPA.

WATER QUALITY EFFECTS

A significant objective of the model is to detail the water quality impacts of categorical standards. The first measure used was comparing the average incremental concenration from POTW's to the water quality criteria. These results are presented below:

Parameter	Aquatic Criteria ug/l	Average Incremental Concentration in Stream (ug/l)	Percent of Criteria
Silver	.12	.15	127
Arsenic	440	.16	0.04
Cadmium	.025	.24	972
Chromium	44	3.2	7
Copper	5.6	1.4	26
Mercury	0.2	0.01	5
Nickel	96	4.3	5
Lead	3.8	1.0	25
Zinc	47	3.2	7
Cyanide	3.5	2.0	58

Cadmium, silver, and cyanide all consume a significant portion of the allowable criteria.

Another measure used by the model to assess water quality criteria was exceedences, which was defined to be an incremental stream concentration for any pollutant contributed by a POTW that exceeded the National Water Quality criteria. This measure, although useful, is limited in that the number of exceedences is primarily driven by the dilution ratio of stream flow to POTW flow. Combined with the very low criteria for some pollutants, this caused exceedences to be fairly insensitive to industrial flow characteristics. The example below serves to illustrate the problems.

Cadmium has an adequate life chronic toxicity of 25 ng/l (0.025 ug/l). The model projects predict cadmium contribution of 3 ug/l from non-industrial sources, of which 50% (1.5 ug/l) will pass through a secondary POTW. Consequently, any POTW with a dilution ratio of 60 to 1 or less will exceed the cadmium limit, even if no industries are present. Pretreatment in any cities in this dilution range will have no effect on causing the plant to exceed the criteria.

Conversely, at POTW'S with very large stream dilution ratios even a large industrial flow with no pretreatment may not cause a violation. Using cadmium, a POTW with 10% of their flow from metal finishing operations would expect their influent cadmium level to increase by 24 ug/l, with 12 ug/l passing through the plant. Added to the 1.5 ug/l effluent concentration from non-industrial sources, an exceedence would be caused only if the dilution ratio for that POTW was less than 540 to 1. Consequently for a significant number of POTW's with small or large dilution ratios, the level of pretreatment has no effect on the number of exceedences. It has also been shown least sensitive to catgorical standards.

To increase the sensitivity somewhat, the model also indicates POTW's that exceed 50% and 25% of the water quality criteria. These numbers implicitly assume that the POTW is not the only discharger on a stream, and sets the other sources of pollutant equal to the POTW concentrations or three times the POTW concentrations arbitrarily. These results are presented in Section 3 of the main body of the report.

The model is much more sensitive to pretreatment options where it predicts absolute values, such as POTW influent concentration, effluent concentration or sludge concentrations. These values are directly calculatd from the input conditions and can be used to indicate the absolute and percentage differences between pretreatment options.

PRETREATMENT PROGRAM COSTS

The costs for developing and implementing a pretreatment program is displayed by the model for both methdologies described in Appendix C-3. These costs are presented below for the 1839 aggregated.

	Method 1	Method 2
1) Development Costs	$35,000,000	$ 91,000,000
2) Implementatoin Costs	$51,000,000	$101,000,000

These figures are probably higher than would actually be incurred (in 1981 dollars) because

- They do not allow credit for programs already in place
- They do not account for programs partially complete
- These figures compute and add a cost for each POTW in cities with multiple POTW's. The city in actuality would incur a cost lower than the sum of all POTW's.

This pretreatment program cost is largely unaffected by the pretreatment option chosen. Even where a POTW can waive certain groups of industries or only regulate a small number of industrial categories they would have to complete most aspects of a pretreatment program.

INDUSTRIAL PRETREATMENT COSTS

The model prepares two industrial pretreatment related costs:

- the cost of pretreatment technology
- the cost of hazardous sludge disposal.

These costs are both shown to be zero today, which only shows the incremental costs of categorical standards. The costs of complete categorical standards are:

Pretreatment Technology - $1.3 billion
Industrial Sludge Disposal - 0.5 billion.

These costs are based on EGD supplied data, and consequently approximate their estimates of total compliance costs. The actual costs of pretreatment in place today will be addressed in the following section.

BASELINE CONDITIONS

One key assumption of the modelling effort is that pretreatment in place today would remain so under all options considered, so only the incremental costs of additional industrial pretreatment was calculated. The rationale for this assumption is that most pretreatment in place has been motivated for other reasons than Federal intervention, and these motivations would continue to exist regardless of the EPA regulatory option chosen. However, without enforceable standards the potential for "backsliding" exists. Consequently the model was used to indicate the net change that has occurred between industrial raw waste loads (from EGD) with no pretreatment and the estimate of current industrial wasteloads used to simulate conditions today. The major model outputs are summarized on Table C.4-I to C.4-IV.

Referring to Table C.4-I, the raw waste loads are estimated (by model) average influent concentrations assuming that no industrial pretreatment were being conducted at the present time. Conditions today are average influent concentrations as they exist today based on an estimate of the current pretreatment level. Categorical standards are estimates averaged from the model assuming complete pretreatment and anticipated categorical standards. The model was used subsequently to generate average effluent, sludge, and stream concentrations as summarized in Tables C.4-II, III, and IV.

Summary of Model Outputs

POTW Influent Projections
(ug/1)

Parameter	Raw Waste Loads	Conditions Today	Categorical Standards
Silver	15	15	14
Arsenic	36	6	4
Cadmium	28	16	12
Chromium	1250	468	89
Copper	693	252	103
Mercury	1.0	0.9	0.6
Nickel	638	203	52
Lead	361	75	60
Zinc	853	410	211
Total Metals	3880	1450	546
Toxic Organics	4100	1820	550

C4-II

Summary of Model Outputs

POTW Effluent Projections
(ug/l)

Parameter	Raw Waste - Loads	Conditions Today	Categorical Standards
Silver	6	6	5
Arsenic	36	6	4
Cadmium	15	9	6
Chromium	427	170	32
Copper	180	66	28
Mercury	0.6	0.5	0.3
Nickel	443	141	36
Lead	160	33	26
Zinc	253	123	65
Total Metals	1520	554	204
Toxic Organics	1091	507	154

C4-III

Summary of Model Outputs

POTW Sludge Projections
(mg/kg)

Parameter	Raw Waste Loads	Conditions Today	Categorical Standards
Silver	31	32	32
Arsenic	0	0	0
Cadmium	41	26	21
Chromium	2360	831	222
Copper	1470	563	274
Mercury	1.5	1.3	1.0
Nickel	571	181	60
Lead	588	147	132
Zinc	1810	923	547
Total Metals	6880	2700	1290
Toxic Organics	1920	913	300

C4-IV

Summary of Model Outputs

POTW Incremental Stream Concentration Projections (ug/l)

Parameter	Raw Waste Loads	Conditions Today	Categorical Standards
Silver	0.2	0.2	0.1
Arsenic	0.8	0.2	0.1
Cadmium	0.4	0.2	0.2
Chromium	11	3.2	0.7
Copper	4.3	1.5	0.7
Mercury	0.02	0.01	0.01
Nickel	14	4.3	1.1
Lead	2.8	1.0	0.7
Zinc	6.3	3.2	1.6

D. BENEFITS APPENDIX

INTRODUCTION

The literature on assessing and measuring benefits associated with improved water quality is diverse and theoretical. This appendix outlines a general approach to estimating water resource benefits, and an overview of the practicality of benefit estimation based on the existing state-of-the-art.

Methodologically, we assume an aggregation approach, estimating benefits associated with diverse water quality uses for case study areas. Numerous case studies of the benefit uses of water quality improvements throughout the United States have been undertaken, thereby providing benchmarks for estimating alternative benefit measures for diverse water uses associated with water pollution control. Individual study area results are generalized for broader regional applications. Similarly, results across all regions are aggregated to yield national benefits.

STAGES IN BENEFITS ESTIMATION

Five stages to benefits analysis are generally applied:

1. Establishing the foundation of the study (defining assumptions);
2. Determining the relationship between physical attributes and environmental quality, with and without improvement;
3. Collecting data to estimate recreation, nonuser, household, municipal, industrial, and commercial fishing benefits; and generalizing benefit results using multivariate techniques;
4. Deriving regional benefits from study area estimates; and,
5. Estimating national benefits.

Each stage is discussed in detail below. Where necessary, appropriate exhibits are presented to facilitate the discussion of particular stages of the analysis.

ESTABLISHING THE FOUNDATIONS OF THE STUDY: STAGE 1

Establishing the foundations of the study requires specification of the study objectives, determining the geographic area of analysis, identification of secondary data sources, defining benefits, specifying assumptions of the analysis and study limitations.

Study Area Boundaries

The initial task is to define the study area boundaries, given the specificity of the study objective(s), to ensure that benefit measures can be attributable to specific uses arising from water pllution control within those study areas. The diversity of area types to be studied and benefits to be analyzed facilitates generalizations. Therefore, the study area(s) might be defined by political boundaries, hydrological basins defined by the Corps of Engineers, functional economic area, or by other means consistent with study objectives. The overall approach is presented in Figure D-1 and details concerning specific elements are discussed below. Individual stages of the analysis are presented sequentially in following sections.

Define Benefits

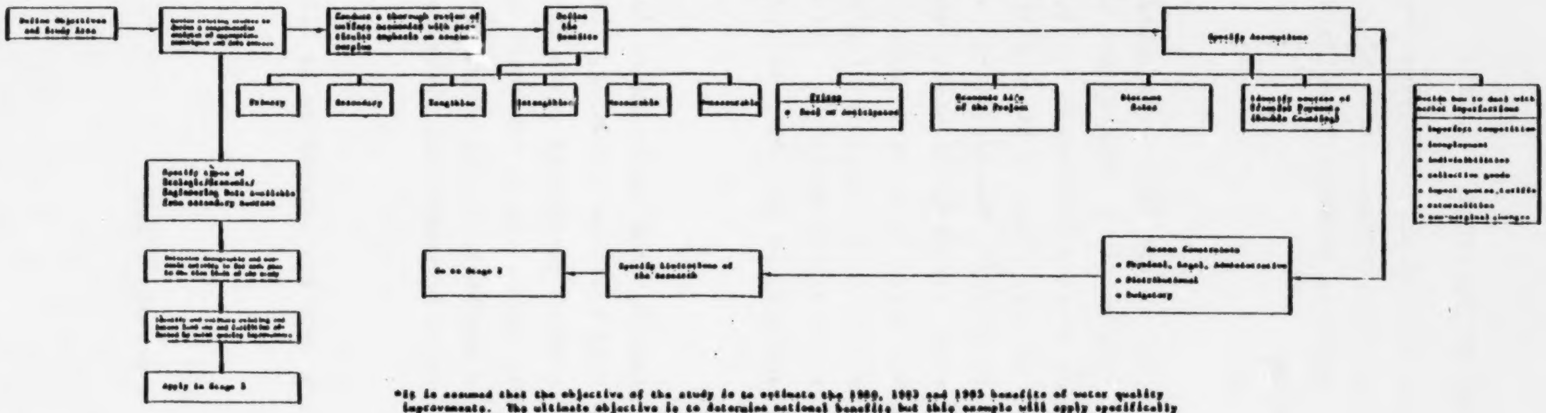
Examples of benefits stemming from improvements in water quality include improvment in recreational opportunities (swimming, fishing, boating, water fowl hunting); reductions in water treatments costs for industrial users; improvements in human health; reductions in household costs associated with water hardness; increases in aesthetic values of water-based odor, taste and appearance; and increased yields of commercial fisheries with potential lower costs to consumers.

Benefits are classified into six categories as illustrated in Figure D-1:

- Primary
- Secondary
- Tangible (possess a market price)
- Intangible
- Measurable
- Unmeasurable.

FIGURE D-1

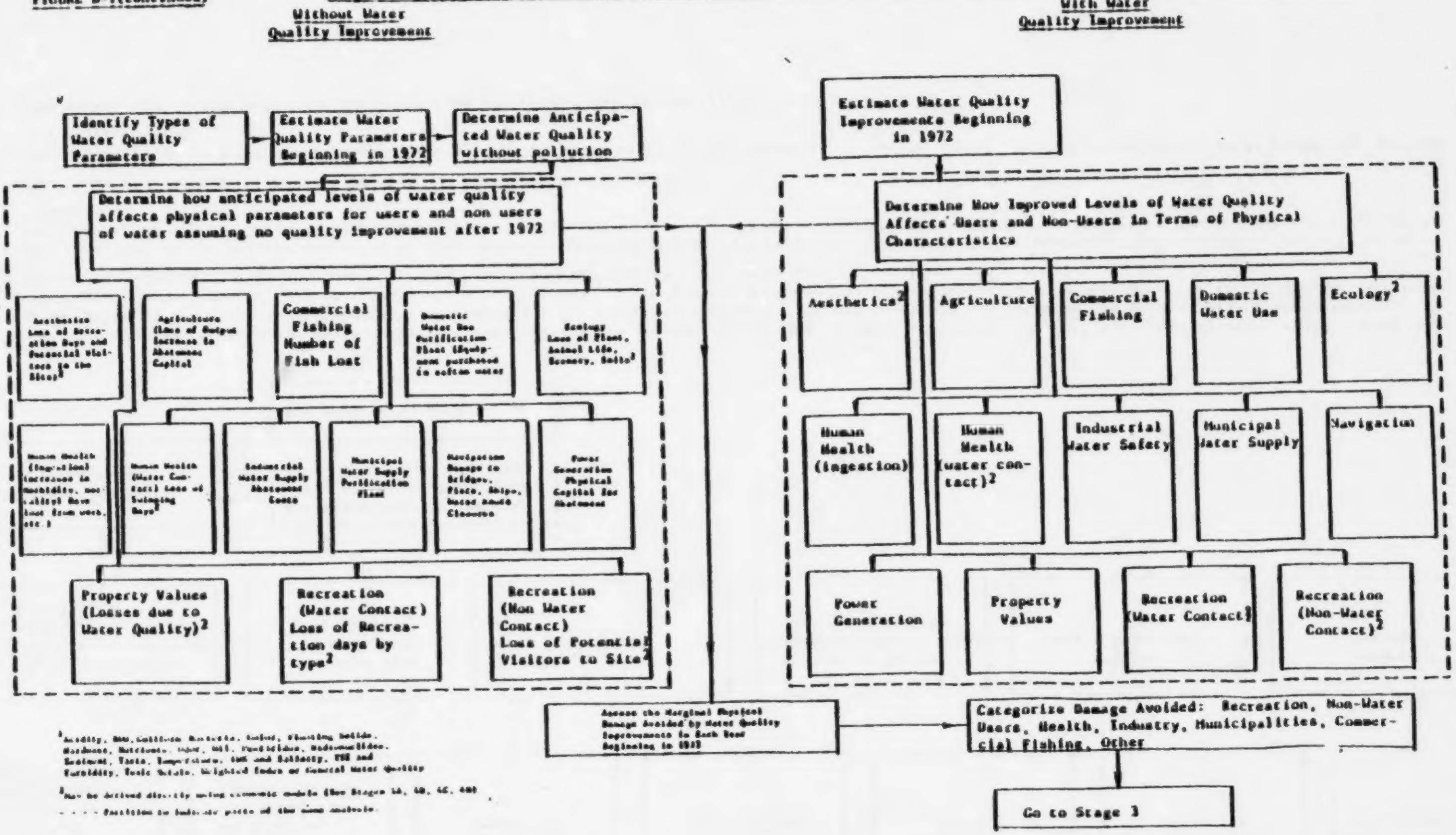
Stage 1: Establishing the Foundations (Defining the Assumptions of the Study)


Define Objectives and Study Area
Conduct a thorough review of welfare economics with particular emphasis on consumer surplus
Define the Benefits
Primary
Secondary
Tangible
Intangible
Measurable
Nonmeasurable
Specify Assumptions
Prices
• Real or Anticipated
Economic Life of the Project
Discount Rates
Identify sources of Claimed Payments (Double Counting)
Decide how to deal with market imperfections
• imperfect competition
• unemployment
• indivisibilities
• collective goods
• import quotas, tariffs
• externalities
• non-marginal changes
Specify types of Ecologic/Economic/Engineering Data available from secondary sources
Apply in Stage 3
Assess Constraints
• Physical, Legal, Administrative
• Distributional
• Budgetary
Specify Limitations of the Research
Go to Stage 2

*It is assumed that the objective of the study is to estimate the 1980, 1983 and 1985 benefits of water quality improvements. The ultimate objective is to determine national benefits but this example will apply specifically to a regional river basin. Estimates of benefits will be projected to the regional level. A series of studies across all regions will yield national benefits.

FIGURE D-1(continued)

Stage 2: Determining Relationship Between Physical Attributes and Environmental Quality (With and Without Improvement)


Without Water Quality Improvement
Identify Types of Water Quality Parameters
Estimate Water Quality Parameters Beginning in 1972
Determine Anticipated Water Quality without pollution
Determine how anticipated levels of water quality affects physical parameters for users and non users of water assuming no quality improvement after 1972
Aesthetics Loss of Recreation Days and Potential Visitors to the Sites²
Agriculture (Loss of Output Increase in Abatement Capital
Commercial Fishing Number of Fish Lost
Domestic Water Use Purification Plant (Equipment purchased to soften water
Ecology Loss of Plant, Animal Life, Scenery, Soils²
Human Health (Ingestion) Increase in Morbidity, mortality) Days lost from work, etc.)
Human Health (Water Contact) Loss of Swimming Days²
Industrial Water Supply Abatement Costs
Municipal Water Supply Purification Plant
Navigation Damage to Bridges, Piers, Ships, Water Route Closures
Power Generation Physical Capital for Abatement
Property Values (Losses due to Water Quality)²
Recreation (Water Contact) Loss of Recreation days by type²
Recreation (Non Water Contact) Loss of Potential Visitors to Site²
With Water Quality Improvement
Estimate Water Quality Improvements Beginning in 1972
Determine How Improved Levels of Water Quality Affects Users and Non-Users in Terms of Physical Characteristics
Aesthetics²
Agriculture
Commercial Fishing
Domestic Water Use
Ecology²
Human Health (Ingestion)
Human Health (water contact)²
Industrial Water Safety
Municipal Water Supply
Navigation
Power Generation
Property Values
Recreation (Water Contact)²
Recreation (Non-Water Contact)²
Assess the Marginal Physical Damage Avoided by Water Quality Improvements in Each Year Beginning in 1972
Categorize Damage Avoided: Recreation, Non-Water Users, Health, Industry, Municipalities, Commercial Fishing, Other
Go to Stage 3

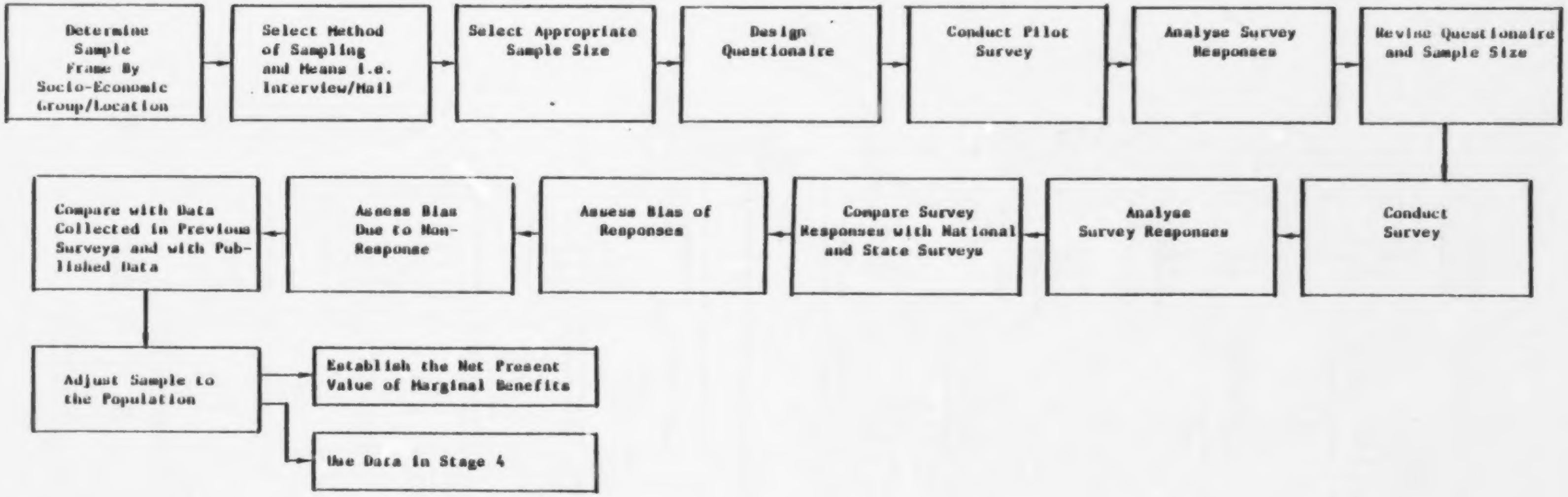
[1] Acidity, BOD, Coliform Bacteria, Color, Floating Solids, Hardness, Nutrients, Odor, Oil, Pesticides, Radionuclides, Sediment, Taste, Temperature, TDS and Salinity, TSS and Turbidity, Toxic Metals, Weighted Index of General Water Quality

[2] May be derived directly using economic models (See Stages 4A, 4B, 4C, 4D)

- - - - Partition to indicate parts of the same analysis.

FIGURE D-1(continued)

Stage 3. Collecting Survey Data to Estimate Recreation[1], Non-user[2], Household[3], Municipal[4], Industrial Benefits[5] and Those Accruing to Commercial Fisheries[6]


Determine Sample Frame By Socio-Economic Group/Location
Select Method of Sampling and Means i.e. Interview/Mail
Select Appropriate Sample Size
Design Questionaire
Conduct Pilot Survey
Analyse Survey Responses
Revise Questionaire and Sample Size
Conduct Survey
Analyse Survey Responses
Compare Survey Responses with National and State Surveys
Assess Bias of Responses
Assess Bias Due to Non-Response
Compare with Data Collected in Previous Surveys and with Published Data
Adjust Sample to the Population
Establish the Net Present Value of Marginal Benefits
Use Data in Stage 4

[1,2] The objective is to ask individuals to state their "willingness to pay" for changes in water quality or how much water quality they would demand at a given price or under specified conditions of taxation. There are two problems: the way questions are asked can be used to create incentives for strategic behavior on the part of respondents i.e., respondents may provide distorted or biased information to influence the final outcome; there may be no incentive to provide accurate responses. Both problems can be overcome by precise questions.

[3] The questions in the surveys conducted to date determine physical damages for each type of household appliance and water distribution facility to the quality of water. These impacts are translated into ranges of economic losses from operating problems and equipment depreciation in a typical household.

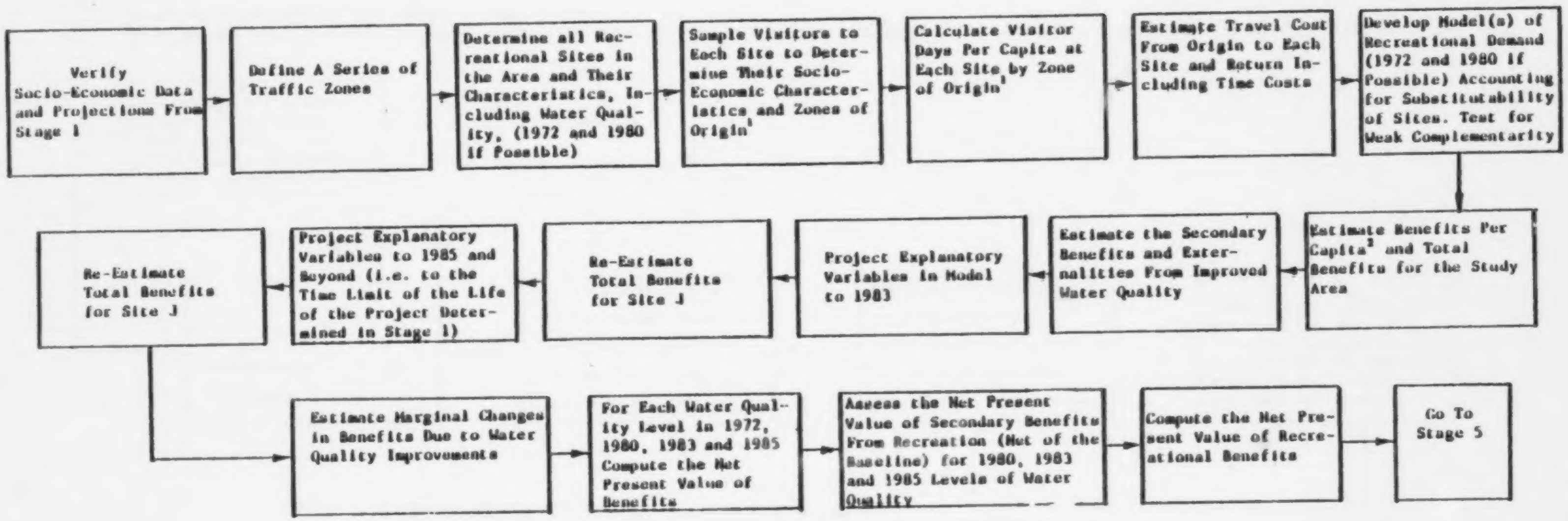
[4] Questions will determine the cost savings due to improved water quality.

[5] The objective is to determine potential cost savings accruing to firms who currently, or in the future, use water as part of their production process e.g., for cooling.

[6] The survey will assess potential losses of fish and revenue due to specific types of pollutants.

FIGURE D-1(continued)

Stage 4A. Estimating the Recreational Benefits of Water Quality Improvements

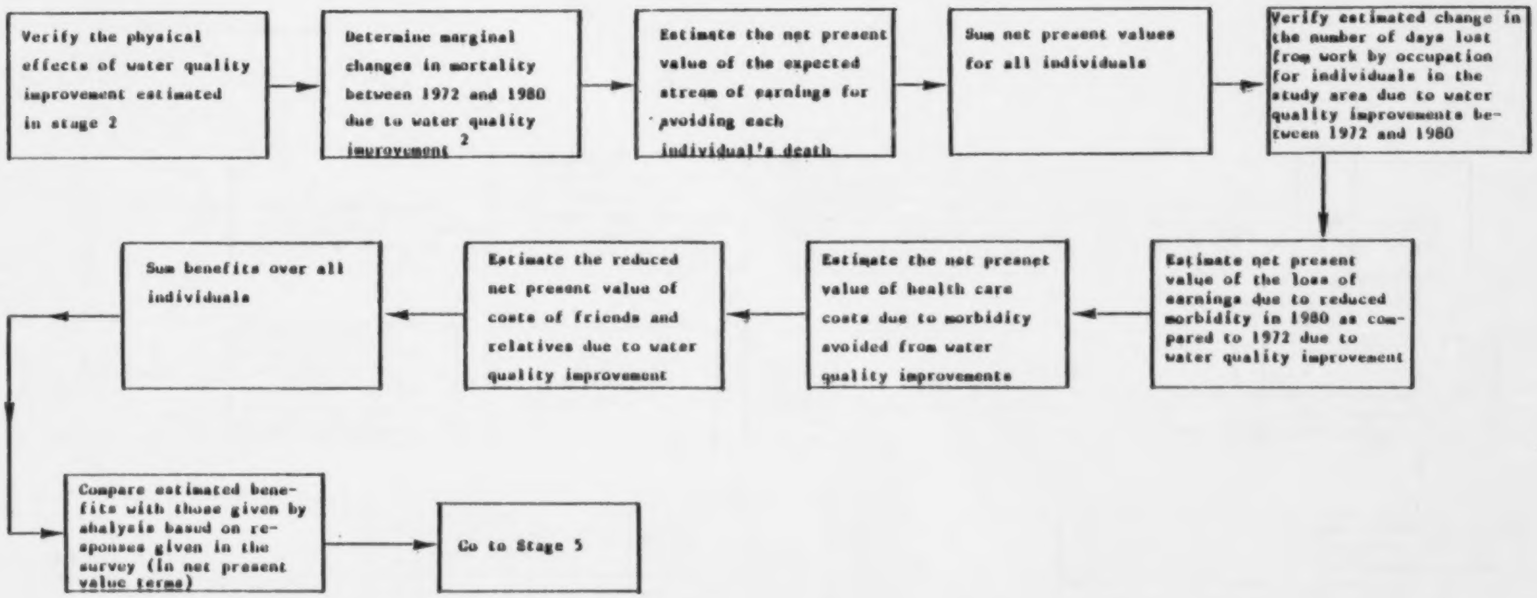

Verify Socio-Economic Data and Projections From Stage 1
Define A Series of Traffic Zones
Determine all Recreational Sites in the Area and Their Characteristics, Including Water Quality, (1972 and 1980 if Possible)
Sample Visitors to Each Site to Determine Their Socio-Economic Characteristics and Zones of Origin[1]
Calculate Visitor Days Per Capita at Each Site by Zone of Origin[1]
Estimate Travel Cost From Origin to Each Site and Return Including Time Costs
Develop Model(s) of Recreational Demand (1972 and 1980 if Possible) Accounting for Substitutability of Sites. Test for Weak Complementarity
Estimate Benefits Per Capita[2] and Total Benefits for the Study Area
Estimate the Secondary Benefits and Externalities From Improved Water Quality
Project Explanatory Variables in Model to 1983
Re-Estimate Total Benefits for Site J
Project Explanatory Variables to 1985 and Beyond (i.e. to the Time Limit of the Life of the Project Determined in Stage 1)
Re-Estimate Total Benefits for Site J
Estimate Marginal Changes in Benefits Due to Water Quality Improvements
For Each Water Quality Level in 1972, 1980, 1983 and 1985 Compute the Net Present Value of Benefits
Assess the Net Present Value of Secondary Benefits From Recreation (Net of the Baseline) for 1980, 1983 and 1985 Levels of Water Quality
Compute the Net Present Value of Recreational Benefits
Go To Stage 5

[1] From Survey Data.

[2] Derived from regression equations.

FIGURE D-1(continued)

Stage 4B. Estimating Health Benefits

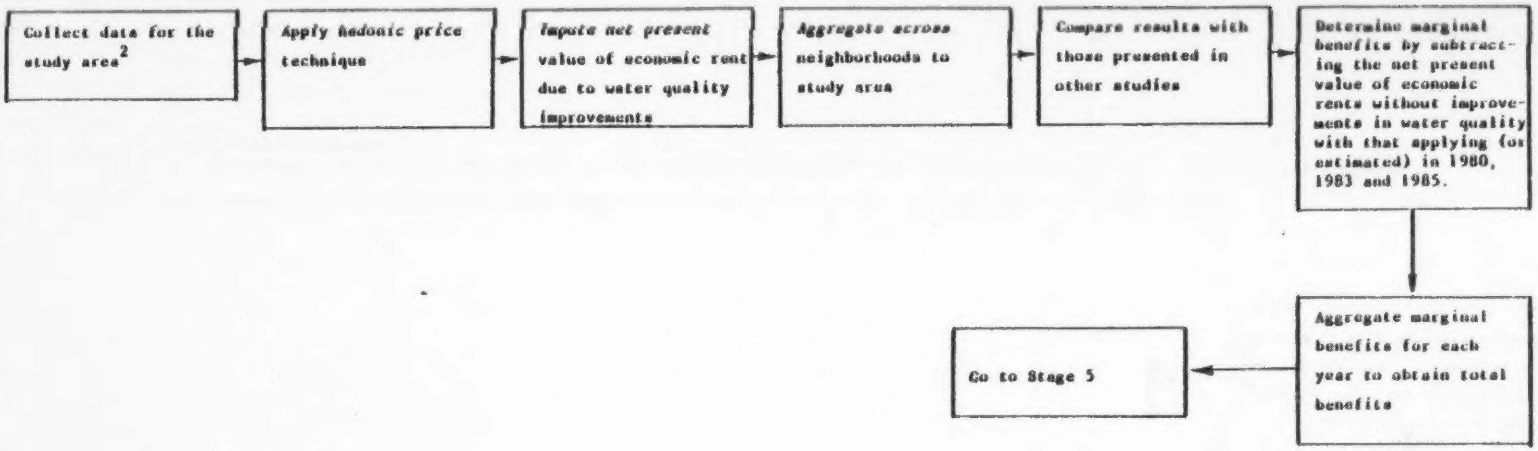

Verify the physical effects of water quality improvement estimated in stage 2
Determine marginal changes in mortality between 1972 and 1980 due to water quality improvement 2
Estimate the net present value of the expected stream of earnings for avoiding each individual's death
Sum net present values for all individuals
Verify estimated change in the number of days lost from work by occupation for individuals in the study area due to water quality improvements between 1972 and 1980
Estimate net present value of the loss of earnings due to reduced morbidity in 1980 as compared to 1972 due to water quality improvement
Estimate the net present value of health care costs due to morbidity avoided from water quality improvements
Estimate the reduced net present value of costs of friends and relatives due to water quality improvement
Sum benefits over all individuals
Compare estimated benefits with those given by analysis based on responses given in the survey (In net present value terms)
Go to Stage 5

1. If it is desirable to obtain national benefits it would be better to collect and analyze U.S. data rather than that for specific regions. The analysis is the same for the nation as for a region.

2. Consider: pollutants which enter through the public water supply; pollutants which enter through the food supplies; effects of polluted water on the transmission of communicable disease; pollutants which enter the body through direct bodily contact with water; pollutants which lead to ecological changes which affect physical and/or psychological health.

FIGURE D-1(continued)

Stage 4c. Estimating the Property Value Component of Non-User Benefits[1]


Collect data for the study area[2]
Apply hedonic price technique
Impute net present value of economic rent due to water quality improvements
Aggregate across neighborhoods to study area
Compare results with those presented in other studies
Determine marginal benefits by subtracting the net present value of economic rents without improvements in water quality with that applying (or estimated) in 1980, 1983 and 1985.
Aggregate marginal benefits for each year to obtain total benefits
Go to Stage 5

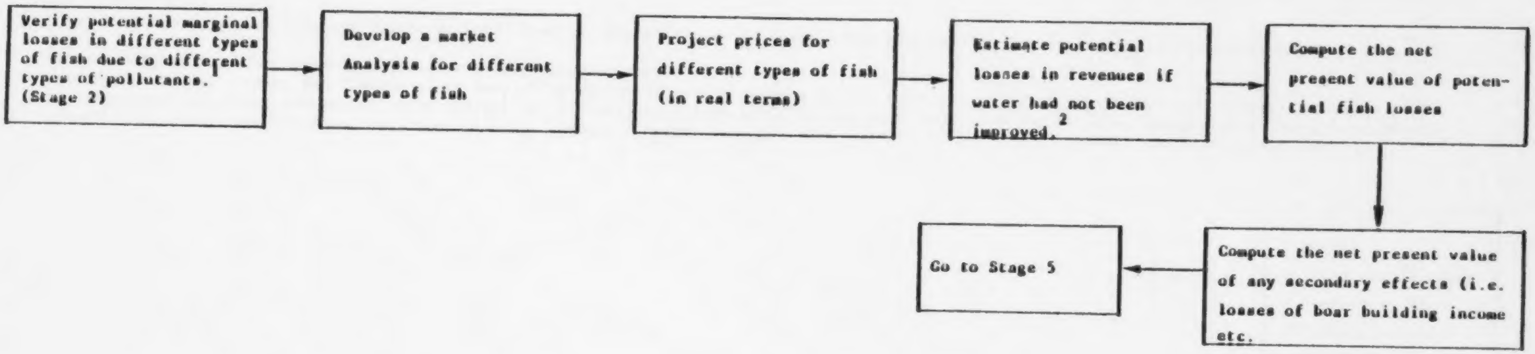
1. Ideally, the ideal study area for such a study might contain a number of lakes that are popular for resort cottage and second home use. If the lakes have different degrees of water quality it is possible to shed light on the water quality-property value relationship. Another possible situation would be a river along which water quality varied considerably because of the locational pattern of dischargers. Existing studies have found benefits to be zero beyond 1 mile from a given body of water.

2. Dombush (1966) estimated that the effect of water quality improvement on property value is limited to an area 4,000 feet from the water: this may reduce data requirements.

3. Property values, characteristics of structure and lot, locational characteristics i.e. distance from shopping centers, parks, other recreational facilities, downtown areas, etc., appropriate measures of water quality, neighborhood characteristics and microeconomic structure, transportation costs to various locations, etc.

FIGURE D-1(continued)

Stage 4D. Estimating the Benefits From Commercial Fishing

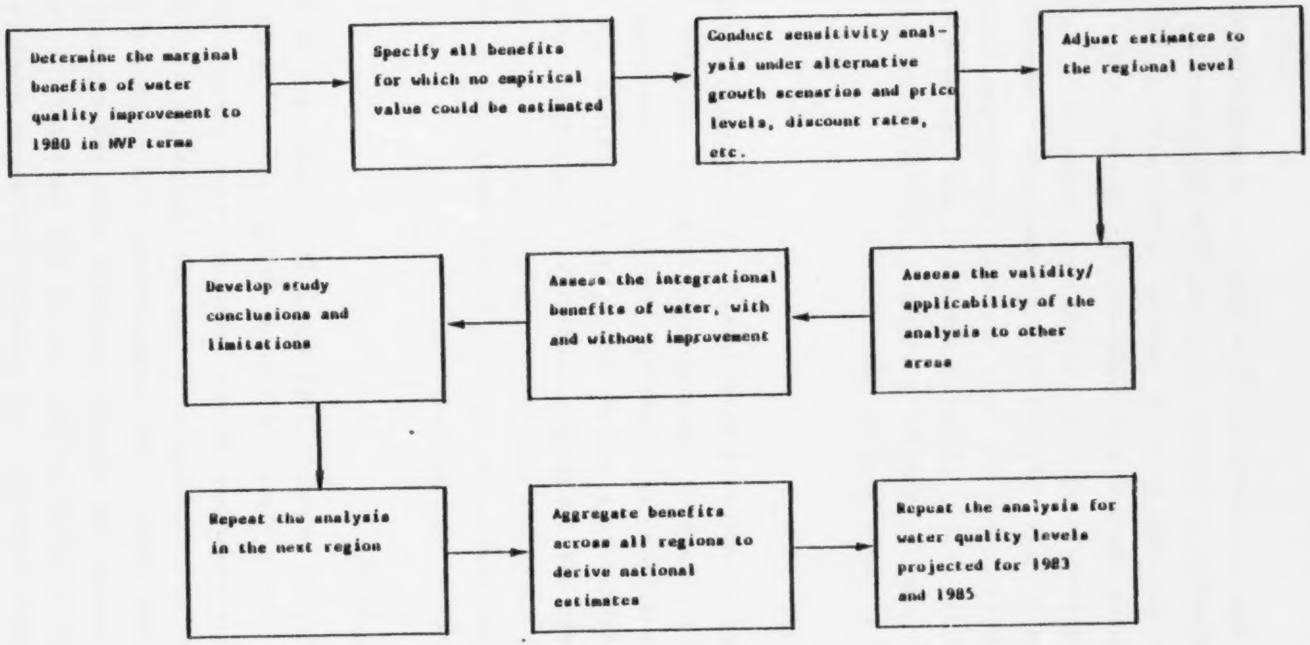

Verify potential marginal losses in different types of fish due to different types of pollutants.[1] (Stage 2)
Develop a market Analysis for different types of fish
Project prices for different types of fish (in real terms)
Estimate potential losses in revenues if water had not been improved.[2]
Compute the net present value of potential fish losses
Compute the net present value of any secondary effects (i.e. losses of boar building income etc.
Go to Stage 5

1. I.e. Compare losses in fish at 1972 water quality levels with losses at 1980, 1983 and 1985 water quality levels.

2. If there were no fish at 1972 water quality levels, benefits might be expenses at the potential revenues from a commercial fishery if one were established.

FIGURE D-1(continued)

Stage 5. Derivation of National Benefits


Determine the marginal benefits of water quality improvement to 1980 in NVP terms
Specify all benefits for which no empirical value could be estimated
Conduct sensitivity analysis under alternative growth scenarios and price levels, discount rates, etc.
Adjust estimates to the regional level
Assess the validity/ applicability of the analysis to other areas
Assess the integrational benefits of water, with and without improvement
Develop study conclusions and limitations
Repeat the analysis in the next region
Aggregate benefits across all regions to derive national estimates
Repeat the analysis for water quality levels projected for 1983 and 1985

Primary benefits may be tangible or intangible, measurable or unmeasurable; similarly, secondary benefits fall within tangible, intangible, measurable and unmeasurable classifications.

Primary and secondary benefits that are directly measurable pose few problems in economic analysis; less tangible and generally unmeasurable benefits have been the focus of intense controversy in the past. However, a general concensus has emerged--particularly in the broader applications of welfare analysis--that specific techniques, grounded in established theory, are applicable to measuring intangible/unmeasurable benefits. Revealed preference theory offers one such approach giving rise to willingness-to-pay survey techniques which, properly developed and implemented, are used to determine and quantify benefit preferences of direct and indirect beneficiaries of water quality improvements.

Collect Secondary Data

Estimating benefits of water quality improvements through the use of economic models (Stage 4) requires collection of secondary data for establishing the functional relationships, scope, and time frame of anticipated analyses. Required data include ecologic, engineering, and economic data to project economic and demographic activity. Identifying and estimating existing and future land uses and faciilties affected by water quality improvements must also be determined and included in the analytical framework for assessing and measuring water quality benefits.

Specific Assumptions

In quantifying benefits over time, it is necessary to make assumptions regarding the general level of prices, the economic life of the project, the discount rate to translate future benefits to net present value terms, and various market imperfections governing the estimation of shadow prices; namely, imperfect competition, unemployment, indivisibilities, collective goods, import quotas and tariffs, externalities and nonmarginal changes which may also affect relative prices. It is also necessary to account for possible sources of double counting. For example, aesthetic benefits may be included in recreational or nonuser benefits. If boating is possible at water quality level, improved water quality should not result in additional benefits to boaters. Many of those issues are well documented in the literature and need no further elaboration.

Limitations of the Research

The previous steps--establishing study area boundaries, defining benefits, indentifying secondary data sources, and explicitly specifying assumptions that must be taken into account--define the study scope. Within this context, it is possible to identify study objectives which might not be possible to achieve.

DETERMINING THE RELATIONSHIP BETWEEN PHYSICAL ATTRIBUTES AND ENVIRONMENTAL QUALITY: STAGE 2

Figure D-1, Stage 2 provides a schematic presentation for determining the relationship between physical attributes of water (pollution levels) and benefits associated with environmental quality, with and without water quality improvement scenarios. Three areas of inquiry are important: identifying types of water quality parameters, estimating water quality parameters, and determining how anticipated levels of water quality impact on physical parameters.

Identifying Types of Water Quality Parameters

The first decision is whether changes in water quality will be indicated by a general index or whether specific parameters are necessary. Studies have used acidity, BOD, coliform bacteria, color, flotation solids, hardness, nutrients, odor, oil, pesticides, radionuclides, sediment, taste, temperature, TDS and salinity, TSS and turbidity, and toxic metals as particular indicators of water quality. On the other hand, individual parameters can be combined and weighted into one or more indices depending on identifiable relationships between water quality parameters and associated impacts/changes in the physical characteristics of water and resultant effects (benefits) on users and nonusers of water.

Estimating Water Quality Parameters

The objective is to determine the ambient concentration of pollutants with and without public policies to improve water quality (Figure D-1, Stage 2). Of importance is the quantitative relationship between residual discharges and ambient concentrations of pollutants, thus making it possible to attribute changes in the output of a particular industry to changes in the ambient concentration of pollutants. Estimates of water quality parameters are known to vary--depending on volume, flow, sampling procedures, and the extent of pollution from natural sources. Quasi-experimental treatment control comparisons (control laboratory experimentation) should contribute to understanding changes in water quality parameters under alternative residual discharge/ambient concentration scenarios.

Determine How Anticipated Levels of Water Quality Affect Physical Parameters

Given levels of ambient water quality, physical effects can be determined; i.e., potential fish loss, increase in morbidity and mortality, damage to bridges, piers, or shipping for various levels of water quality. The link between water quality and its impact on physical parameters is causal, one that accounts for the physical damage avoided by water quality improvements versus the situation without public policy maintaining or improving water quality.

ESTIMATING BENEFITS FROM SURVEY DATA: STAGE 3

Data used to determine the economic benefits of water quality improvements are largely derived from surveys. Figure D-1, Stage 3 outlines a general methodology for survey design and implementation for estimating recreation, nonuser, household, municipal, and industrial benefits as well as those accruing to commercial fisheries.

Data are collected using either a stratified random sample or sampling of the entire population, depending on the objectives of the study and the level of accuracy sought. Pilot surveys provide a ready means of evaluating the adequacy of the questionnaire by reducing incentives for biased responses and providing indications as to the accuracy of specific responses. Based on results of pilot surveys, survey instruments can be revised and sample sizes adjusted. Estimates of benefits can be derived for the population of households, municipalities, and industry.

Willingness-To-Pay Survey Techniques

One approach to estimating benefits through survey techniques is to have individuals state their "willingness-to-pay" for a given stream of benefits associated with water quality improvements. Questions used to derive willingness-to-pay responses must place the individual in a situation where he/she can understand the objectives of water quality improvement such that he/she can imagine the consequences of his/her response; i.e., questions should include concrete data and accurate descriptions of alternatives. The objective is to create as real a situation as possible rather than to present hypothetical scenarios.

Willingness-to-pay surveys must be directed toward discerning particular water level uses and their relative worth to respondents, an approach that permits investigating trade-offs among differing use levels and their prospective values to respondents. Such an approach has been used extensively for estimating recreational benefits, both for users and nonusers.

ESTIMATING BENEFITS OF WATER QUALITY IMPROVEMENT FROM ECONOMIC MODELS: STAGE 4

Economic models have generally focused on assessing the benefits and costs associated with particular water level uses--recreation, health, the property value components of nonuser benefits, and commercial fishing are examples that have received extensive treatment in the literature and are discussed below. However, other use benefit aspects covering navigation, municipal water supply, agriculture and domestic water users should also be considered in a more comprehensive treatment of the subject.

Recreational Benefits

Figure D-1, Stage 4A provides a detailed schematic chart for estimating the recreational benefits from water quality improvements. Inputs into the estimation procedure follow directly from Figure D-1, Stage 1, which provides the socio-economic data base for undertaking the analysis.

As the demand for outdoor recreation grows due to population growth and increased leisure time, benefits of water pollution abatement will also rise. Particular benefits will derive from each type of recreational use of water resources: fishing, boating, swimming, sightseeing, camping, water fowl hunting, fish and animal preservation, and skiing are examples. Benefits can be defined by the amount an individual is willing to pay (in license fees, travel costs, etc.) to enjoy the different types of water recreation; i.e., the amount that could be collected from users of recreation areas (in the form of licenses, sales of hunting rights, etc.) if it were possible to charge for service and amenities.

A number of studies have used travel costs as a means of estimating the demand for recreation where frequency of visits to a site is a decreasing function of distance from the site. The cost of travel increases with distance from the site because of monetary and intellectual considerations. Hence, a demand curve for recreation may be derived by plotting frequency of visits against distance. This method computes the consumer surplus or economic benefit of the site to an individual as the amount saved over the traveling costs of the user coming from the longest distance. It easily lends itself to estimates of recreational benefits except in the case of unique wildlife or scenic facilities.

A typical demand function is described by Freeman, (1979) and may be of the form

$$V_{ijb} = V_j(P_{xj}, Di, ti, hi, Q_j, R, {}_{..k}, M_i)$$

where

V_{ijb}: Number of visits of individual i to site j for purpose of boating

P_{xj}: Vector of prices of entry to various sites

Di: Vector of distances from the residence of individual

ti: Vector of travel times to the various sites

hi: Cost of travel time to the various sites

Q_j: Indicators of water quality at the various sites (this may be specified as the concentrations of different types of pollutants)

$R_{,..k}$: Indicators of recreational facilities and amenities at each site

M_i: Vector of individual socio-economic characteristics including income.

The dependent variable can be adjusted to account for other types of recreation besides boating.

Health Benefits

Figure D-1, Stage 4B provides a diagrammatic procedure for estimating health benefits and follows directly from the preceding discussion of Stage 2. For people in the labor force, the human capital approach can be used to derive the expected net present value of future earnings which an individual might have earned had death been avoided. The benefit of preventing a death of an individual in any year, H_i, can be derived from:

$$H_i = \sum_{t=1}^{t} PtEt/(1 + i)t$$

where

Pt = probability of the individual surviving to year t

Et = earnings of an individual in year t

i = discount rate.

These benefits, H_i, therefore represent the potential loss of output to society, and will obviously depend on the socio-economic characteristics of the individual. The estimate of H_i often expresses the net of the individual's worth to society, relecting the individual's consumption.

In addition to the valuation of reduced mortality due to water quality improvement, account should also be taken of the reduced costs of health care, and the indirect costs of morbidity due to lost earnings. An essential part of the analysis is to determine the number of days of lost activity or restricted activity due specifically to adverse water quality. This part of the study may thus involve defining specific relationships between levels of water quality and various types of illness or disease.

Property Value Component of Nonuser Benefits

Figure D-1, Stage 4C outlines the general approach for estimating the property value component of nonuser benefits associated with improved water quality. It is assumed that as the quality of water in a stream or lake improves, people are willing to pay to locate nearer to that water if they consider it an amenity. Hence, property and land values near the amenity will increase. Benefits of water improvement will be greatest at the water's edge and will decline with distance from it.

Typically, a hedonic price approach is used to isolate the change in property or land values due to changes in water quality from that due to structural or neighborhood characteristics. The hedonic equation may be used to estimate the implicit price of water quality and may be of the form

$$R_i = W(P_i, N_i, Q_i, D_{ij}, D_{i1\ldots k})$$

where

R_i: Value of property (expressed as a rent using assessed values, sometimes adjusted for taxation)

P_i: Vector or property characteristics

N_i: Vector of neighborhood characteristics (including zoning, public services and taxes, density, racial composition)

Q_i: Level of water quality

D_{ij}: Distance to water body

$D_{i1\ldots k}$: Distance to other social amenities (local schools, parks, stores, hospitals, place to work, cultural centers, highways).

This method can be used to determine how rapidly water quality improvement effects decrease with distance from the water body. Selection of the study area is particularly important: an ideal area would include as much variation as possible along water body types and geographic locations so that the influence of water quality can be identified. If water quality improvements are to change individuals' valuation of a water resource, a consideration is that people are aware of changes that have taken place.

Benefits from Commercial Fishing

As in preceeding sections, the procedural approach for estimating benefits from commercial fishing is presented in Figure D-1, Stage 4D. Benefits of water quality improvement are estimated as the net increase in income which results from improvement--the net value of production less marginal cost. Improved water quality also leads to benefits in the form of reduced costs of maintaining vessels, bait and other operating capital.

Consideration must be given to an analysis of the abundance of fish resources and the potential increases in catch with varying levels of water quality improvements. Secondary considerations are increased commercial yields on fish packing plants, and the indirect effects of increased expenditures of the additional income earned in local areas.

ESTIMATING NATIONAL BENEFITS: STAGE 5

Emphasis in preceding discussions has been on the explicit identification and measurement of benefits that, in the general context of contemporary literature, are area specific. Intangible and unmeasurable benefits can be proxied, albeit crudely, through "willingness-to-pay" surveys premised on a revealed preference theory approach. Initial ordinal values can be interpreted in terms of monetized values. Less difficulty is encountered with physically observable changes that directly impact on land values, commercial fishing, recreational uses of water, and health effects--all of which can be observed on-site and directly measured through survey techniques/economic models.

National benefits--quantifiable changes in water uses due to improved water quality--are approximated by a bottoms-up approach. Area specific case studies can be generalized to other comparable areas and/or modified to account for different types of areas experiencing similar water quality/use changes. Estimates are adjusted to a regional basis and aggregated across all regions to derive national estimates making allowance for externalities in the cases where one regions's gain may be another's loss. The general procedure is outlined in Figure D-1, Stage 5.

APPENDIX E

MONETIZING BENEFITS

In this report the benefits of pretreatment are described in both qualitative and quantitative terms. The quantitative measures of benefits for all of the 2000 POTWs studied are: the change in pollution loadings as a result of the pretreatment options and the improvements in water quality as indicated by the elimination of exceedances. However, for those cases where exceedances are eliminated, this report goes further by attempting to measure some of the benefits of cleaner water. Specifically, this report measures the dollar value of achieving designated recreation uses (such as swimming, fishing, and boating). This section describes the methods used to make these recreation use value estimates. Other benefits of cleaner water were not addressed.

E.1 INTRODUCTION

Initially, several estimation techniques were considered for this analysis. These included (1) apportioning existing national benefits estimates and assigning a portion to pretreatment measures and (2) extrapolating total pretreatment benefits from detailed case studies. But apportionment approaches are hampered by the lack of adequate data for assigning benefits to water bodies. And for case studies, sophisticated benefits analysis techniques could not be applied to a sufficient number of cases to provide representative results due to time and resource constraints. Therefore, a hybrid technique was developed. This hybrid approach combines readily available local information on stream capacity and affected population with recreation value factors estimated from several national and site-specific studies. It proved to be feasible and performed well when tested against other techniques recently used by EPA.

The approach used here provides an interesting indication of the actual and potential benefits of pretreatment options. However, the approach does not provide an adequate basis for making cost-benefit tradeoffs in program design and application. This is because of several important limitations. The approach measures only the benefits of recreational uses of water, neglecting POTW upsets, effects on sludge toxicity, industrial and municipal costs to treat water prior to use, and health effects. Because it was not possible to relate recreation uses of water to particular levels of various toxic pollutants, the analysis assumes that no recreation takes place if there are any toxic exceedances. Finally, this analysis neglects the presence of pollutant sources other than POTWs; this lends to an over-estimation of likely water quality (before and after controls) and an under-estimation of potential control costs to achieve water quality levels. Other limitations also exist and are discussed later in this section.

In the next subsection (E.2), basic approaches to benefits analysis are briefly described and compared, to put the approach used here in perspective. In subsection E.3, the methodology employed is described in detail. In subsection E.4, the limitations of the methodology are discussed. In subsection E.5, this benefits estimation approach is tested by comparing the results to recent and available EPA case studies.

E.2 APPROACHES TO BENEFITS ESTIMATAION

This section attempts to place the benefits estimation approach used here in perspective by describing its relationship to approaches used in the past. The discussion is brief, and does not describe alternative benefits estimation techniques in great detail. A more general and complete discussion of benefits analysis for water pollution control is provided in Appendix D.

E.2.1 Previous Studies

In general, past studies have either examined improvements for particular bodies of water (case studies), or attempted to estimate the nationwide benefits of improving all water quality to a uniformly high level.

Case studies can include relatively sophisticated water quality modelling to estimate actual changes in water quality. Local information on use levels and stream capacities can be collected. Surveys can be used to relate travel distances or costs to water quality, or to collect reports on subjective willingness to pay for improved water quality. All of this information can be combined to estimate the value that affected individuals place on the change in their recreational opportunities. (Past studies show that enhanced recreation value is usually the largest component of total benefits from an improvement in water quality.) Good case studies provide the best available estimates of the value of improved water quality. However, these studies require a great deal of data and are typically expensive and time consuming.

National benefits studies use generalized estimates of the value of recreation activities, based on the estimates of values at particular times and places derived in case studies. These estimates are then extrapolated to the national level using aggregations of such factors as surface area of affected water bodies or population affected. Water quality modelling is typically not undertaken; the studies measure the benefits of improvements in water quality, and assume that the regulations will produce such improvements. Recreation is assigned similar values in all locations, without regard for local tastes or available alternatives. (We will call these assigned values "national benefits factors.") Extrapolations are necessarily crude, and subjective judgments about the weight to be accorded particular case studies is inevitably important.

E.2.2 This Study

The pretreatment program will affect a large number of locations and will have different effects on water quality in different places. As a result, local detail is important but many cases must be examined. The methodology used in this study is designed to make local detail manageable within time and resource constraints. This methodology can be viewed either as a simplified case study approach, or as an exercise in extrapolation of national benefits factors that is somewhat more case specific than existing national benefits studies.

The approach is like a case study because it uses case specific predictions of changes in water quality, and uses local information about affected populations and the recreation potential of the affected water body (based on its size). The approach simplifies the case study approach considerably (and moves in the direction of national benefits studies) by using national benefits factors, and by not measuring actual changes in use. While this approach allows many cases to be examined quickly and economically, the results in any particular case may over- or under-estimate actual benefits. Case-by-case benefits estimates are aggregated here to average sources of error that are not systematic, before benefits are compared to costs.

E.3 DETAILED METHODOLOGY

The methodology used here measures recreation use benefits in two ways: 1) as the value of use multiplied by the level of use, and 2) as the value of proximity to clean water multiplied by affected population. Both approaches rely on the use of appropriate national benefit factors, which are taken from earlier studies (primarily national benefits studies). In the first approach, boating and fishing benefit factors are combined with an estimate of actual fishing and boating participation levels based on stream reach area and recreation planning standards. (The estimation method assumes recreation capacity will be fully utilized.) In the second case, a different benefits factor is combined with affected population, estimated as the population of contiguous counties. Benefits other than recureation use are not estimated.

E.3.1 Sample Selection

The benefits factor approach can be applied in any case where basic data on stream area are available. It is used here to measure actual benefits in cases where a POTW control option leads to elimination of all water quality exceedances for the designated stream segment. To the extent that stream area and affected population in these cases are typical, the benefits measured are indicative of the benefits that could be achieved by eliminating exceedances in other cases.

Data sufficient to calculate the effects of regulation on exceedances were available for 650 POTWs from a population of 2000. This sample is believed to be representative of the general population. In 325 of these 650 cases, some exceedances occurred in the absence of control. In 22 of the 325 cases with exceedances, the exceedances were eliminated by the control options. Benefits were analyzed for 17 of these cases. The cases analyzed are representative of about 60 cases in the total population of 2,000 for which controls could be expected to eliminate all exceedances.

E.3.2 Benefits Factors

Case study estimates of benefits provide a series of examples of the value of recreation. The examples involve different individuals in various places and times, and different activities that are more or less affected by improvements in water quality. Existing national benefits studies have relied on these case study results to estimate general values for boating, fishing, and swimming. These values are expressed in terms of dollars per user or household over a given time period. In conjunction with EPA, this analysis reviewed existing national benefits studies to select the most reasonable and well founded benefits factors that are available. The benefits factors used for this analysis, and their sources, are given in Table E-1. Other typical factors that were not used are also presented for comparison purposes.

One set of factors used in this analysis measures the use value of boating and fishing; these factors are given in dollars per individual user per day of use. Boating benefits were estimated to be about $17 to $30 per user per day, and fishing benefits to be about $15 to $30 per user per day. These benefits factors are properly used in conjunction with estimates of the change in actual use of a stream segment that results from an improvement in water quality.

Table E-1

ESTIMATED PER CAPITA BENEFITS IN 1981 DOLLARS

Type of Benefit	Amount	Source
RECREATION		
Boating*	$16.76 - 29.73 /person/day	NCWQ (1978)
Fishing	$15-30 /person/day	Russell and Vaughan (RFF/EPA 1981)
	(catfish-trout)	Charbonneau and Hay (1978)
Swimmable, fishable and boatable water (includes non-user benefits as well)	$35-45 /household/year	Gramlich (1977)
NON-USER**		
Fishable waters	$111 /household/year	Mitchell and Carson (forthcoming)
OTHER		
Drinking Water	40% of local treatment costs	Barker & Kramer (1973) Bramen (1960)
Health	$300,000-3 million per fatality avoided	Thaler and Rosen (1975) Bailey (1979)

* Boating benefits do not include canoeing, water skiing, or sailing

** Non-user benefits are for all U.S. waters, and includes aesthetics, preservation (future generations) value, and option value.

Another factor measures the benefits of attaining waters of "swimmable" quality; this factor is given as \$35 to \$45 dollars per "local" household per year. This last factor is for improvement from water that is not useable for recreation to water that is boatable, fishable and swimmable; therefore it incorporates the use value of all of these activities. Clean water also creates new recreation opportunities that are valuable even if they are not used; the benefits factor used here includes such non-user benefits as preservation and option values; after application of this factor, results were adjusted to include only user benefits. This benefits factor is properly used in conjunction with estimates of the number of households within range of the stream segment experiencing the water quality improvement.

E.3.3 Estimation of Stream Size, Use Levels, and Household Affected

This study does not measure actual use levels (if any) now occuring for the stream segments of interest, nor does it estimate the change in use levels that can be expected to occur on a particular body of water experiencing an improvement in water quality. Instead, the study assumes that attaining water quality thresholds trigger full capacity use. It is assumed that use is achieved only when exceedances are eliminated.

Where water can support boating or fishing, this study assumes that the water is fully utilized. The estimates of "full use" capacities for fishing and boating activity used for this analysis are based on the characteristics of the affected stream segment — e.g. stream length (miles), surface area (acres), and number of available recreation days.

For this analysis, each POTW was assumed to be affecting one stream reach (the section of a stream between two confluents). For the cases in which a POTW was located in the upper half of a stream reach, that reach was used. Where a POTW was located in the lower half of a stream reach, the next reach was used. (This reach would begin at the first major confluent downstream of the POTW, and extends to the next major confluent.) The total surface area of the affected segment was determined by multiplying the average width of each reach by the length of the reach.

Boating and fishing capacity and recreation days are based on recreation planning standards adopted by the state of Ohio in its State Comprehensive Recreation Plan. (The boating capacity estimate is based on canoeing, while boating benefits factors used in this study specifically exclude canoeing. However, this capacity figure is the best that could be located for this purpose.) One hundred ten (110) use-days were assumed, based on 90 weekend days in a nine-month season, plus 20 vacation days, with zero use at other times. This approach provides only a rough notion of capacity, and may not accurately represent potential use levels for any particular stream reach. However, the fishing capacity and use days estimates are supported by an Army Corps of Engineers study showing 87 fisherman days per acre per year for Mosquito Creek, Pennsylvania.

Estimates of the number of households affected by an improvement in water quality were derived by examining Census Bureau 1980 Advanced Reports data for counties bordering or containing the stream segments of interest.

E.3.4 Estimating Benefits

As indicated in Section E.3, two slightly different methods were used here to estimate benefits. The first derives user benefits from boating and fishing by multiplying stream use capacities by the values per person-day of those uses. The second approach estimates total user benefits by multiplying the number of "local" households by a separate benefits factor intended to capture annual household benefits for fishable/swimmable waters. With both of these approaches, it is assumed that water quality is improved from a level that does not permit any recreation to a level that permits boating, fishing and swimming.

These two methods of estimating benefits are independent of one another (except that both are affected by stream length) and therefore provide checks on each other. In general, the "households affected" measure should give higher values for benefits, because it captures swimming benefits. However, estimates of user benefits using either technique can be overstated. The "households affected" measure can overstate benefits when a large population center is located near a stream reach of limited capacity. The capacity estimation technique can overstate benefits when population levels are low relative to stream capacity. This approach does not use population as an input; it asks how many users can be supported rather than asking how many users will actually be added. These capacity estimates should be matched with benefits factors that measure the benefits of potential use, but instead they are matched with factors for boating and swimming that are based on actual rather than potential use. Where benefits estimates based on one approach are much greater than benefits estimates based on the other, it is likely that the higher estimate is unreliable.

Table E-2 provides an example of the amount of activity that would be required for boating and fishing user benefits to each equal $1 million. The table also shows the number of affected households that would be required for the aggregate user benefits of swimmable waters to equal $1 million. This substantial level of benefits can be achieved with fewer than 100 boaters or fishers per pay, or as few as 25,000 local households.

E.4 ASSUMPTIONS AND LIMITATIONS

Strong assumptions and significant simplifications were needed to apply this approach to estimating benefits. Therefore, it is important to understand the major limitations of the approach in considering the reliability of its results. Judgements about reliability should also consider the evidence in section E.6 on the good performance of this approach in comparison to more sophisticated benefits estimation approaches recently applied by EPA in three case studies. The limitations of this approach do not appear to have introduced any major or systematic bias in the estimates of benefits that result for these cases.

Table E-2

RECREATION BENEFITS MATRIX

Level of Attained Designated Use	Number of Users	User Benefits
° Boating* ($17-30 /person/day	91 - 161†	$1,000,000
° Fishing ($15-30 /person/day)	91 - 183§	$1,000,000
° Swimmable ($35-45 /household/year) (includes non-user benefits)**	33,333 - 42,857¶	$1,000,000

* Boating benefits do not include water skiing or sailing.

** Non-user benefits are assumed to be 50% of user fishing benefits, and include aesthetics, preservation (future) generation value and option value.

NOTES:

† The Ohio State Comprehensive Recreation Plan (SCRP) adopts a standard of 40 persons/mile/day maximum canoeing capacity. The number of user days per year is estimated by multiplying this standard times the number of recreation days available (weekends and holidays in a nine month season plus 20 days of vacation time) times the number of navigable miles on the particular body of water.

For example, using an average (user) boating benefit of $23.50/person/day, a body of water having 9.67 navigable miles and located where 9 months out of the year provide suitable weather (90 days of weekends and holidays, and 20 days of vacation time), would yield $1 million per year in user benefits (40*110*9.67*23.5).

§ According to the Ohio SCRP, potential use of a fishery is 1 fisherman per acre of surface water per day. With 110 recreation days of full use per year, maximum use would be 110 fisherman per acre per year. This use estimate is supported by an Army Corps of Engineers study at Mosquito Creek which estimates potential use of a fishery at 87 fisherman per acre per year. Thus, for a particular body of water, an upper bound estimate of users per year can be made by multiplying 110 times the number of surface acres available.

For example, using an average (user) fishing benefit of $22.50/person/day, a body of water with 404.04 acres of surface area would yield user benefits of $1 million per year (110*404.04*22.50).

Table E-2 continued

Recreation Benefits Matrix

NOTES continued:

This estimate of fishing benefits does not account for bank fishing, but only for boat fishing. For bank fishing, a standard of 20 fisherman per day per river mile would be used to estimate benefits.

¶ Estimating user benefits using this benefits factor for swimmable, fishable, and boatable water, would involve estimating the population of counties or towns in an area adjoining the body of water on either side. To arrive at total user benefits from this aggregate measure, non-user benefits amounting to 50% of user fishing benefits would be subtracted out after fishing benefits are calculated as above. For example, suppose that the body of water used in the fishing example above runs through one or more counties having a total of 37,500 households. Then, using an average aggregate benefit of $40 per household per year, total user benefits for swimming, fishing, boating plus non-user benefits would be $1,500,000 (40*37,500). Subtract out the $.5 million in non-user benefits would yield total user benefits of $1 million.

Assumptions and limitations are discussed here roughly in order of importance. In each case an attempt is made to indicate whether the assumption introduces a bias for which the direction can be predicted or controlled, and to indicate the likely direction of bias if possible. A summary section discusses the implications of all these limitations for uses of the analysis results.

E.4.1 Use of Thresholds

This analysis treats benefits as a threshold phenomena, and assumes that there is only one threshold of importance. These assumptions introduce different biases in different cases. The use of any threshold will lead to underestimates of benefits in cases where thresholds are not reached, because no benefits will be found if those cases are examined using this approach. The use of thresholds will lead to overestimates of benefits in most cases where thresholds are crossed, because benefits attributable to a large change in water quality may all be assigned to the small change that crosses the chosen threshold. Even if the threshold phenomena existed in practice or was officially established for toxics at the state level, it is unlikely that a single threshold would be appropriate for boating, fishing and swimming. The use of a single threshold exacerbates the problems inherent in the threshold approach. With one threshold rather than several there will be more cases in which thresholds are not crossed, and a greater overestimate of benefits in cases where thresholds are crossed.

E.4.2 Other Dischargers

Due to data limitations, this approach treats POTWs as the only source of pollutant discharges. As a result, exceedances probably appear less frequently and are eliminated more easily in the model than in practice. In addition, all benefits of cleaner water are attributed to controls on POTWs, when eliminating exceedances may typically require the control of other sources (such as direct industrial dischargers). This limitation probably contributes to an overestimate of benefits in the cases examined.

E.4.3 Estimation of Use Levels

The analysis makes no adjustments for prior use of stream reaches, and does not account for factors (other than limited population) that may prevent "full use" of a stream reach as defined by recreation planning standards. These assumptions may introduce a bias toward overstated benefits.

E.4.4 Single Stream Reaches

The analysis looks at only one stream reach for each POTW. Confining the analysis to a single stream reach will lead to underestimates of benefits, because improving the water quality in the given reach will make it more likely that uses and benefits can be achieved downstream. This source of under-estimation tends to offset any over-estimation resulting from the "full use" assumption described above.

E.4.5 Local Value of Uses

The national benefits factors used in this analysis do not reflect the local value of particular uses, and so are unlikely to be appropriate in specific instances. It is not known whether this results in over or underestimation of benefits for the particular cases examined. The aggregation of case results probably smooths out much of the error from this source.

E.4.6 Recreation Days

This analysis assumes 110 recreation days for all parts of the country (9 months of weekends plus 20 vacation days), on the basis of estimates intended for use in the Ohio/Pennsylvania region. In areas with a less harsh climate, or a harsh climate but a greater propensity toward water quality sensitive winter recreation (e.g., ice fishing), this will lead to an underestimate of benefits. Benefits may also be underestimated if a stream reach is more heavily used by vactationers than is assumed here. In other regions benefits may be overestimated.

E.4.7 Other Data Limitations

This analysis ties benefits estimation to estimates of affected population and to estimates of the area of water affected controls on the POTW. These estimates are quite crude, and errors will introduce biases in the estimated level of benefits.

2.5 LIMITS ON THE USE OF RESULTS

The results of this analysis of 17 cases could be used only to assess the cases actually examined, or could be extrapolated to all other cases where exceedances are eliminated, or to the entire population of POTWs. However, the limitations of this analysis make it unreliable for some purposes, so results must be used with caution.

For the cases examined, many factors that could not be controlled or evaluated can introduce errors in the estimates of benefits. Therefore for single POTWs small differences (i.e., less than a factor of two) between costs and benefits should not be considered significant. The direction of bias resulting from all of these factors in a particular case cannot be determined; however, when cases are aggregated a systematic bias toward overestimation of recreation use benefits is likely to prevail, allowing a more informed use of results. Even after averaging, however, results should not be used to make cost/benefit tradeoffs in program design. This is because of the remaining systematic bias, and because too few cases were examined here to prevent attaching undue significance to potentially unreliable results in one or a few cases.

The results for the 17 cases examined here can easily be extrapolated to the 60 or so cases in the entire population of POTWs for which exceedances could be expected to be eliminated. However, substantial uncertainty exists about the representativeness of the sampled cases. POTW flows, stream flows, stream reach and width, and affected populations are all relevant here, and no attempt has been made to compare these factors for sampled and unsampled cases. Therefore, extrapolated results would be of unknown reliability.

Finally, there is a major question as to whether the benefits measured here should be compared to all pretreatment costs, or only to the costs of the cases examined. Cost-benefit ratios will differ radically in the two cases, and reasonable people can differ on which approach is most appropriate. Thus, the results of using either approach cannot be conclusive in determining whether costs exceed benefits for the pretreatment program as a whole.

This issue turns on particular biases in the estimating techniques used here. On the one hand, this analysis probably overestimates benefits for the stream segments that were examined (those where thresholds were crossed); on the other hand, benefits exist in many cases where this approach was not applied because it would not capture benefits. The factors that contribute to an overestimation of benefits in the cases where thresholds are crossed also contribute to an underestimation of benefits in other cases. If cases were properly divided into these two groups, attribution of measured benefits to more cases might result in a more accurate picture of benefits in an average case. But if too few cases are identified as involving elimination of all exceedances, benefits would be seriously underestimated for the population of POTWs as a whole.

This kind of misclassification is likely to exist in this case. The model used to predict exceedances assumes that POTWs are the only dischargers, and that they discharge into pristine water; partly because of these assumptions half of all cases examined involved water so clean that no control was needed to avoid exceedances. In actual practice receiving waters would not be so clean, and exceedances that could be eliminated through control would probably be more common.

The decision made here is to exclude the costs in the latter set of cases from cost/benefit comparisons. However, some readers may wish to take the other approach, assume that substantially all benefits have been captured in the cases examined, and compare these benefits to total costs for all the POTWs. These costs are reported in this study, so that the reader can generate any desired comparisions.

The benefits found in the cases examined here are indicative of potential benefits from eliminating exceedances in other cases. Comparing potential benefits to the costs incurred for control in cases where exceedances were not eliminated provides some indication of whether additional expenditures on pretreatment might be worthwhile.

E.6 TESTS OF RELIABILITY OF RESULTS

This section compares the results of the benefits estimates made using the benefits factors techniques described above to results of using three other and more sophisticated techniques. These comparison cases were chosen because they are the most recent case studies that were available. The benefits factors approaches described above were applied to the same stream segments examined in these recent case studies.

Comparison of results indicates that simple benefits factor approaches can produce benefits estimates in the same range as more sophisticated approaches. However, these comparisons are not conclusive because significant biases are possible using benefits factors techniques as they are applied here, and only a small sample of cases is being examined. There cannot be a high level of confidence that the performance of the benefits factor approaches in these cases is representative of their performance in general.

The case studies examined three rivers (the Mahoning, Black, and Monongahela rivers, in Ohio and Pennsylvania) and applied three different approaches to estimate benefits. There approaches were Participation Models (PIE-C/1), Planning Standards (PIE-C/2) and Willingness to Pay (PIE-C/3). (Some of the results of the case studies used here are preliminary, and subject to change.)

The participation model predicted changes in levels of participation, given changes in the supply of boatable and fishable water, changes in type of fish caught and average size of catch, and socioeconomic factors.

The planning standards approach is conceptually very similar to the "capacity times value" approach used here to measure boating and fishing benefits. In addition, common data were used for affected area of water, population in the vicinity, and recreation days, and similar data were used for benefits factors. The major differences in the results of using the planning standards approach and the benefits factor approach are probably the result of adjustments for previous use and sensitivity to kinds of boating and fishing in the planning standards approach.

The willingness to pay approach was based on a survey that addressed the value of improving all U.S. waters to swimmable quality.

A comparison of the results using the three alternative estimation techniques and a benefits factor technique is shown in Table E-3. The table gives total user benefits by river, total user benefits aggregated for all three rivers, and a breakdown of fishing and boating estimates by river. The benefits factor method produces benefits estimates that are comparable to those produced by these other techniques. When results for all three rivers are aggregated, the benefits factor technique compares even more favorably.

For each of the three rivers analyzed in the study, the benefits factor method estimates for fishing and boating user benefits estimates are closer to estimates made with the very similar planning standards technique than with the less similar participation model technique. When fishing and boating estimates for the three rivers are aggregated, the ranges calculated by different methods become closer. Before totalling, the benefits factor and planning standards fishing aggregate estimates differ by 38 percent on the low end and by 13 percent on the high end, and the boating aggregate estimates are nearly identical on both ends. After totalling, aggregate (fishing and boating) estimates differ by 20 percent on the low end and by less than nine percent on

Table E-3

TOTAL USER BENEFITS FOR ALL METHODS (IN $ MILLIONS)

Case Study	PIE-C ESTIMATE*	SCI ESTIMATE
Mahoning River		
(fishing and boating)	1.19 - 1.86	
	4.47 - 6.43	4.71 - 8.64*
(fishing, boating, swimming)	7.74 - 9.64	6.41 - 8.54**
Black River		
(fishing and boating)	2.89 - 3.74	
	1.79 - 2.82	1.73 - 3.16*
(fishing, boating, swimming)	3.57 - 6.56	2.81 - 3.72**
Monongahela		
(fishing and boating)	9.00 - 12.53	
	12.66 - 17.99	9.30 - 17.82*
(fishing, boating, swimming)	27.31 - 28.54	21.39 - 28.79**

* All PIE-C estimates are preliminary. Some revisions may be made.

AGGREGATE ESTIMATES FOR ALL THREE RIVERS
(in million dollars)

	PIE-C/1	PIE-C/2	SCI
Fishing	8.2 - 9.9	10.9 - 14.0	7.9 - 15.8
Boating	4.9 - 8.2	8.0 - 13.3	7.8 - 13.8
Total	13.1 - 18.1	18.9 - 27.2	15.7 - 29.6

	PIE-C/3	SCI
Fishing, Boating, Swimming	38.6 - 44.7	30.6 - 41.1

NOTES ON PIE-C DATA USED FOR SCI ESTIMATES

* For Fishing: used PIE-C estimates for surface acres: 839, 318.6, and 3640 respectively.

For Boating: used PIE-C estimates for river miles (length): 44.5, 16, and 44 respectively; and recreation days (110).

** For Fishing, Boating, Swimming: used PIE-C estimates for population: 638,500 274,909 2,219,848 individuals respectively; and then assumed that there are 3 individuals per household.

Table E-3 (continued)

BREAKDOWN OF FISHING AND BOATING ESTIMATES

Mahoning River

	PIE-C/1	PIE-C/2	SCI
Fishing	.25 - .39	1.91 - 2.42	1.38 - 2.77
Boating	.94 - 1.47	2.56 - 4.01	3.33 - 5.87
Total	1.19 - 1.86	4.47 - 6.43	4.71 - 8.64

Black River

	PIE-C/1	PIE-C/2	SCI
Fishing	2.35 - 2.83	.73 - 1.02	.53 - 1.05
Boating	.54 - .91	1.06 - 1.80	1.20 - 2.11
Total	2.89 - 3.74	1.79 - 2.82	1.73 - 3.16

Monongahela River

	PIE-C/1	PIE-C/2	SCI
Fishing	5.60 - 6.72	8.29 - 10.52	6.01 - 12.01
Boating	3.40 - 5.81	4.37 - 7.47	3.29 - 5.81
Total	9.00 - 12.53	12.66 - 17.99	9.30 - 17.82

the high end. Thus, when taken as a total, the individually aggregated fishing and boating estimates are quite close to one another.

The situation with respect to the swimming, fishing, and boating estimates is similar. Whereas the individual case study estimates differ on the low and high ends by 21 and 13 percent, 27 and 75 percent, and 28 and one percent, respectively, the aggregate estimates differ by only 25 percent on the low end and by only nine percent on the high end.

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